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SPECIAL ELECTRIC-SHOVEL AND STEAM-SHOVEL FINISHING A 10-MILE SECTION OF BOULDERS, ON OLANCHA DIVISION, LOS ANGELES AQUEDUCT.

(See page 97.)

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EDITORIAL

JUDGING by the leaks in the new Southern Pacific steel suburban cars during the recent rainstorm, the company is watering its rolling stock. Railroad Commission please note.

CHALLENGES to mortal combat were hurled back and forth during the recent session of the French National Congress at which M. Raymond Poincaré was elected President. Fortunately more dangerous missiles were not used, so no one was injured.

INCREASE in the number of members of Congress has so badly overcrowded the House that benches of the good old district-school type will have to be substituted for the revolving chairs in which members were wont to loll in comfort. Thus rotation in office receives another blow.

ENGINEERS throughout the world unite in extending congratulations to Mr. Robert W. Hunt upon the award to him of the John Fritz medal. Mr. Hunt, more than any other individual, has stood first for scientific accuracy in steel making, and while the John Fritz medal can add nothing to the position he has won in the world of technology, it is of some account to have been deemed worthy of a place among the immortals of engineering by a jury of his peers.

ACCURATE data concerning the cost of engineering work is highly prized by engineers. Data of this kind, to be of genuine service, must be prepared so that full cognizance may be taken of the conditions under which the costs were obtained. Mr. O. W. Peterson's article on 'Ditch Excavation on the Los Angeles Aqueduct' will be appreciated not only on account of the authoritative cost data it contains, but also for the insight that it gives of the conditions existing on the ground.

LA REDAKCIO ANONCAS, ke ĉiuj demandoj pri tiu ĉi gazeto, aŭ ĝia enhavoj, adresotaj al tiu ĉi oficejo, esperante redaktitaj estos responditaj en la sama lingvo.

The above states in Esperanto: "The editor announces that all questions concerning *Western Engineering* or its contents, addressed hereafter to this office, written in Esperanto, will be replied to in the same language."

The auxiliary international language, Esperanto, is taking such a place in general use that it is rapidly becoming of real value to technicians in the exchange of their observations and ideas. The *Scienca Gazeto*, published in Paris, gives a monthly review of scientific work in Europe, and from it an article describing the low-temperatures laboratory at Leyden has already been translated and published in our December 1912 issue. With our rapidly increasing foreign circulation, it is felt that our sphere of activity may be enlarged if our readers and subscribers beyond the seas are made aware that we appreciate the benefits of the auxiliary language and have placed ourselves in position to participate in its benefits.

"BACK to the farm" is the slogan that is used to the limit nowadays to entice the city dweller from

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his high stool and ledger. Glowing advertisements paint vivid pictures of the wonderful accomplishments of irrigation, and are so designed as to give the impression that scientific knowledge and hard labor are not necessary adjuncts to winning a competency from the soil. Nothing could be further from the truth. That the marvelous development in irrigation has opened new possibilities in gainful occupation cannot be denied, but that many persons have assumed the responsibilities of farm life without the remotest understanding of the work they were undertaking is, unfortunately, also true. As is usual, the progress of a new idea is marked by derelicts who have fallen by the wayside. The Reclamation Service is doing much to minimize these occurrences, and with that end in view has held a number of conferences during 1912 which should have a lasting and beneficial effect upon the work of developing the remaining arid land sections in the West. Mr. F. H. Newell, director of the Reclamation Service has attended all of these meetings and is directing his energies, as far as lies within his power, toward the elimination of wild-cat land-boomers, who care only for their own profit, and nothing for the fate of those who, caught by specious promises and alluring advertisements, must gain a living from the soil. The principal problems under discussion at these various conferences were, how to find the man who really desires a farm; how to pick from such those who are capable of successfully cultivating an irrigated tract of land; how to gain the irrigation farmers' confidence and make valuable suggestions to him as to how to determine the honesty and ability of those who are financing irrigation projects and offering irrigated lands to prospective settlers; how to place information before people who are seeking it; and, of course, how to eliminate such agencies as are known or suspected to be untrustworthy. The greed for profit has caused promoters to sell irrigated lands indiscriminately to all who succumbed to the wiles of the salesman, without regard to the effect that the inevitably large number of failures would have upon public opinion. Had the same amount of energy been displayed in attracting the right kind of settlers and in helping them to success as was shown in the marketing of securities, irrigated land would have lost none of the popularity it had a few years ago. The promoter who wants 20 per cent for his efforts, the banker who wants 20 per cent for handling the securities, and the land salesman who also wants his rake-off, leaves little for the farmers after they have succeeded in draining the property. These are the mistakes made in the past that need broad and constructive management to correct. Irrigation will prove to be a great boon; it is only in the maladministration of the details that disappointments and failures have arisen.

The San Francisco Water Situation

Negotiations between the officials of San Francisco and representatives of the Spring Valley Water Company for the purchase of the property of the latter have been abruptly ended by the rejection of the city's offer. The rejected offer, in detail, was as follows:

Cash offered	$37,000,000.00
Released money	650,000.00
Searsville tract and Market-St. lots (company's valuation)	500,000.00
1850 acres at Lake Merced at $1250 per acre (Farrington)	2,312,500.00
Total offer	$40,462,500.00

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Less bonds	19,017,000.00
	$21,445,500.00
280,000 shares of stock at market quotation, $63.50.....	17,780,000.00
Total bonus to stockholders.	$ 3,665,500.00
Bonus for each share of stock.....	$13.00
Market value	63.50
Value under city offer.....	$76.50
Bonus on bonds above market quotations, $92⅞	$1,354,970.00

Negotiations between the city and the water company have been going on intermittently for years. In November 1909, the Spring Valley Water Company made an offer to sell its properties for $35,000,000, which was rejected by a vote of the people in January 1910. The offers of August 1912, and subsequent thereto, have been fully discussed in our editorial columns. The point of difference in this last and possibly final disagreement was only $500,000, an amount which, while large in itself, is small when compared to the total involved and to the importance of the question to the people of San Francisco. In the hearings recently held in Washington concerning the grant of the Hetch Hetchy permit, Mr. Fisher indicated that the present source of supply was entitled to first consideration before an attempt should be made to develop any other source. We approved of this decision, and believe that nothing should be done to injure or depreciate the value of any existing utility, provided that such utility is fulfilling its obligations to the community which it serves. A prejudiced and biased press succeeded in preventing, through its influence over the voters, the purchase of the Spring Valley properties in 1909 for $35,000,000. That the purchase was not consummated at that time is a matter to be regretted. Nevertheless, it would appear from the statement above, that the city's offer was not only fair, but far in advance of the market value of the property as reflected by the quotations in the Stock Exchange. It is often said that he who buys at a price in excess of the market value is lacking in financial sense, yet there are many factors influencing stock prices other than the present earning capacity of the property it represents. Such factors as the potential possibilities of the properties as a source of future supply must also be considered. There is no doubt that every possible contingency was taken into consideration by the men acting in behalf of the city. Conclusions were not hastily formed, but were reached through weeks of careful study. The price offered, when compared with the present market value of the stock and other securities, justifies the belief that the city has been not only fair, but generous. On many of the points at issue during the previous negotiations, the city offered to split the difference, but the Spring Valley officials refused to retreat from their original position. As the city has submitted an ultimatum offering $37,000,000 for the Spring Valley property, permitting the company to retain 1850 acres at Merced, the Searsville lands, and the Market-street lots and providing for an equal division of the money impounded in court, any further overtures must proceed from the Spring Valley company. While the rights of property are clear and incontestible, nevertheless there are considerations that are entitled to prior preference. The welfare of a community of half a million people must be taken into account, and it seems certain that the offer made by the city is as liberal as could be made with any expectation that it would be ratified by the voters. It will not be surprising if reprisals

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are undertaken by the city officials. A new move has already been made through Mr. Percy V. Long, City Attorney. Mr. Long has drawn up a bill, which has been introduced in the Assembly by Mr. W. A. Sutherland. amending the Public Utilities Act and aiming to bring about a settlement of the price question between the city and the Spring Valley company. The proposed bill upsets all previous legal practice with regard to condemnation proceedings, and provides that when a municipality desires to take over any public utility and cannot agree with the owners upon a price, the Railroad Commission may be called upon to take testimony, and on this testimony may fix the sum which the municipality is to pay. The constitutional amendment defining the powers of the Railroad Commission states: "No provision of this Constitution shall be construed as a limitation upon the authority of the Legislature to confer upon the Railroad Commission additional powers of the same kind or different from those conferred upon the Railroad Commission in this Constitution, and the authority of the Legislature to confer such additional powers is expressly declared to be plenary and unlimited by any provision of this Constitution." The new bill provides that the same procedure in taking testimony shall be used as is now in vogue for ascertaining the valuation of the property of public utilities. At the end of the hearing, when the report has been made, either the city or the public utility is given the right of review before the Supreme Court of the State. When the decision of the Commission has become final, the city is to file a condemnation suit in the Superior Court, and it is mandatory upon the judge to accept as conclusive the compensation fixed by the Railroad Commission. Opinions have been expressed that the real test of the validity of the bill will come when the Supreme Court is called upon to pass on the constitutionality of the clause above cited. Pooh-Bah, of comic opera fame, exercised many functions, but the Railroad Commission, in the exercise of the powers granted to it under the Public Utilities Act, illustrates the superiority of twentieth century enlightenment. In the meantime, during all this embroglio, the wee sma' voice of the consumer pipes up with the question, "When am I going to get an adequate water-supply?" Court proceedings are not the most expeditious things in the world, and should Mr. Long's bill become a law, and the latter go through all the tortuous mazes of the courts before going into effect, it would probably be years before anything could really be accomplished. Mr. S. P. Eastman, vice-president of the Spring Valley company, is reported as having cast serious doubts upon the ability of the present mains and distributing systems to handle any more water than the amount consumed by the city at present. Mr. Eastman certainly is in a position to know, and if extensive additions will need to be made to the Spring Valley mains, pumping stations, and distributing systems to render them adequate to supply the demands of the city even in the near future, the city ought to be at work on the extensions now. The passage of the Long bill would defeat its own purpose in that the delay involved by the certainty of long-drawn-out court proceedings would be a serious detriment to the welfare of the city, while the Panama-Pacific Exposition is only two years away. The entire question should be submitted to an impartial board of arbitration without delay.

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REVIEW OF THE MONTH

STORMS have been the predominating characteristic of the month; snowstorms, windstorms, rainstorms, thunder-storms, and Storms in and out of the position of State Mineralogist. Of these, the first four are the usual trimmings that adorn the winter season. Without them, the wheels of industry would cease to revolve, the orchard and the farm would no longer yield, and the power generated in the mountains would no longer be the cause of strife between the public-utility corporations and the railroad commission.

DISCHARGING a capable, honest, and efficient public servant on a flimsy pretext, however, is another matter. The mining interests of California, having endorsed the candidacy of Mr. W. H. Storms, had reason to anticipate that under his régime, together with the coöperation of an administration pledged to efficiency and economy, a new era of effective aid to the great mining interests of the state was about to be inaugurated. Now, after Mr. Storms has held office only a little over a year, it appears that the hopes of the mining men have been builded upon sand, and that they must revise their views as to what they may expect from the present Administration. Charges that led to Mr. Storms' dismissal were in effect that some $15,000 had been expended and nothing accomplished; that employees had been permitted to draw upon the cash on hand, leaving tags in its stead, one tag in the cash-drawer being over a year old; that the minerals in the museum had never been catalogued; and other charges of minor importance. Mr. Storms' reply to these charges shows the matter in a totally different light. It is shown that the failure of the Bureau to accomplish all that its officials desired was due to failure of the Legislature to furnish money for field expenses; that no money was advanced to employees except for salaries earned or money expended on state account; that this system of book-keeping was one of long standing, and that by it the state had never lost one cent; that the system itself had been abandoned months ago; and that there is a five-volume catalogue of the museum now available. The real point of difference between the Governor and Mr. Storms was the discharge for incompetence by the latter of two employees who had been appointed at the request of the Governor. Mr. Storms' statement to this effect is endorsed by the Board of Trustees, who are in direct control of the State Mining Bureau, and it was at their order that the employees were discharged. It is not a very edifying spectacle to contemplate the invocation of the powers of the Board of Control by the Governor of a great state in order to find a pretext for ousting an official who would not permit his office to be run for the purpose of paying political debts. Governor Johnson, in answer to Mr. Storms, characterizes him as an ingrate, which is interesting as an indication of the Governor's state of mind but is not responsive. Mr. A. H. Ward, chairman of the Board of trustees, since supplanted by another appointee, characterizes the entire matter

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as a piece of political jobbery, and the Governor might do well to remember that the construction of a political machine, for which the interests of the state are being sacrificed, may prove to be only a little old last year's model when the election of November 1914 is over.

BY way of pleasing contrast, the administration of Mr. James Rolph Jr., as Mayor of San Francisco affords a welcome relief. No consideration other than personal fitness governed the selection of Mr. M. M. O'Shaughnessy as city engineer. Mr. Adolph Judell, formerly an assistant city engineer, has been made president of the Board of Public Works because the excellence of his work proclaimed his fitness for the assumption of added responsibilities. Neither of these gentlemen are politicians. Neither holds either ward or precinct in the hollow of his hand. They are engineers, and engineers who have made good in their chosen profession while employed in private work. They will do the same thing for the city of San Francisco. It is unfortunate that appointments to public office on the basis of personal fitness are still sufficiently rare as to warrant comment.

IT is a common thing to find fault with the bearer of news that is not agreeable. Mr. Bion J. Arnold, who has been making a series of studies relating to the traffic problems and future growth of San Francisco, has seriously upset the equanimity of several of the daily papers by his estimates of future growth for San Francisco and the suburban tributary area, including Oakland and Alameda county. Mr. Arnold shows that San Francisco may reasonably expect to have a population of 1,000,000 in 1945, while that of the commuter district including San Francisco, now having a population of 728,000, will reach 1,000,000 by 1919. The San Francisco dailies have evidently taken Mr. Arnold's statements concerning the commuter district as meaning only the city of Oakland, when as a matter of fact, the term 'commuter area', in addition to the city and county of San Francisco, includes practically the whole of Alameda county and the greater portion of Marin, San Mateo, and Santa Clara counties. The estimate made by Mr. Marx of the population of San Francisco by 1940 is something over 1,500,000; Mr. Dockweiler's for the same period, 1,800,000; Mr. Freeman's is 1,600,000, while Mr. Schussler's estimate agrees substantially with that of Mr. Arnold. It is both inspiring and patriotic for the many estimable gentlemen who have achieved success through mercantile pursuits to rush into print when aspersions seem to be cast upon the city wherein their interest lies, but while predictions as to the future growth of cities may not be considered in the light of an exact science, the views of men who have made a life study of such matters are clearly entitled to precedence over those of a layman, however good a guesser he may consider himself.

ANNOUNCEMENT that the California Atlantic Steamship Company, known as the Bates & Chesebrough line, has been withdrawn, is the cause of much regret in shipping circles. The reasons ascribed for this action are, briefly: rate-cutting on the part of their competitors, inadequate transfer facilities on the Isthmus and on the Atlantic seaboard, the wreck of one of their steamers, and inadequate capital. Of these, the first and last

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are undoubtedly the most serious. When a rate war between two transportation companies begins, Providence always seems to take the side of the man having the most money, and the weaker competitor usually sees before long that nothing short of divine intervention can postpone or prevent the inevitable end to such a contest. Economically, we, as a Nation, are still far from being civilized, and the waste due to rate wars is not only unnecessary but stupid. The water freight carrying competition instituted by the Bates & Chesebrough line has resulted in the transportation of thousands of tons of freight without adequate compensation to the carriers, and has left the Pacific Mail Company in possession of the field awaiting the coming of the next competitor who may have the temerity to try conclusions.

THE Luckenbach Steamship Company seems to be undeterred by the fate of the Bates & Chesebrough line and is apparently ready to try its luck in competition with the Pacific Mail and American-Hawaiian companies. Application has been made to the Board of Harbor Commissioners for wharfage facilities, and through billing privileges have already been granted by the Panama railroad. The company has declared its intention to inaugurate a direct freight service between San Francisco and Balboa, the western terminus of the Panama canal. Two steamships, already in San Francisco harbor awaiting a cargo, will go into this service, and within a month another steamer of 6000 tons will be added to the fleet, thus assuring a bi-weekly service between San Francisco and Panama, scheduled to commence on February 4. It is hoped that the new-comers will successfully cope with the situation.

PLANS for the division of the Southern and Union Pacific railroads go merrily on. As was expected, the plan now in process of elaboration between the Attorney-General and the railroad officials includes turning control of the Central Pacific, with some 1561 miles of track and various branch lines, over to the Union Pacific, which will constitute a transcontinental line in competition with the Southern Pacific Sunset route from San Francisco to New Orleans. The Central Pacific has been in control of the Southern Pacific since 1899 and was a potent factor in the hands of the latter company in keeping the Union Pacific in line, until Mr. Harriman merged all three systems under one control. The complications regarding the ownership of stock are very difficult to straighten out, and the fact that for fourteen years there has been no market for Central Pacific stock due to its being owned entirely by the Southern Pacific, imposes quite a task upon those concerned in determining a proper basis for its exchange. It will be some time after all the legal and other steps have been taken before the effect of the change in administration will become manifest. California shippers generally are opposed to the transfer of ownership of the Central to the Union Pacific, as the location of the executive offices at Omaha rather than San Francisco lends color to the belief that California interests will suffer by absentee landlordism. However there is no use in borrowing trouble. The course to be pursued having been determined, there is nothing to do but wait, and see what will happen.

SUPPLEMENTAL data are given in a report of Mr. John R. Freeman dealing with the Hetch Hetchy water-supply project, which was filed at Washington, and of which copies have

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been received by the Board of Army Engineers in San Francisco. In this report Mr. Freeman compares the cost of Hetch Hetchy development with that of other suggested sources of supply. Two stages of development are used as bases of comparison, one calling for a daily delivery of 240,000,000 gallons and the other of 400,000,000 to 500,000,000 gallons. Mr. Freeman estimates that 240,000,000 gallons daily can be brought from Hetch Hetchy to San Francisco and Oakland at a first cost of $44,664,000, which quantity of water is stated to be sufficient for San Francisco and all the other bay cities until 1950 at least. The figures given include also the development of 150,000 horse-power which can be utilized for the generation of electricity for municipal power and lighting service. The additional cost for developing the Hetch Hetchy source in 1950 to supply 400,000,000 to 500,000,000 gallons per day is estimated at $17,490,000. Of the various alternative sources, Mr. Freeman has estimated the cost of developing the McCloud project in the first and second stages at $55,477,000 and $16,858,000, respectively; Sacramento river filtered water, $66,690,000; Stanislaus and Mokelumne rivers, $63,329,000; American and Cosumnes rivers, $69,210,000.

ELECTRIC traction has received great impetus through the grant by the Federal Government of a permit to the Great Falls Power Company to transmit over public domain, under Government regulations, power for the electrification of 450 miles of main-line track of the Chicago, Milwaukee & Puget Sound railroad between Tarlowtown, Montana, and Avery, Idaho. The grant covers a period of fifty years and is in accordance with an Act of Congress of March 4, 1911, relating to electrical transmission, telephone, and telegraph lines. According to the report of the Stone & Webster Corporation, the Great Falls Power Company was organized in May 1910 to take over the property of the Great Falls Water-Power & Townsite Company. The source of power-supply consists of a series of rapids and falls in the Missouri river from Black Eagle falls to Sheep creek, a distance of about twelve miles, in which the river drops a distance of 460 feet. Power-sites and abutting property necessary for the full development of all the potential power within the area mentioned are said to be owned by the company. Developments have already been made at Black Eagle falls and at Rainbow falls, with transmission line at Butte and Anaconda. Four water-wheels are installed at Rainbow falls having an aggregate capacity of 36,000 horse-power. In the July 1912 issue, a more extended abstract of the Stone & Webster report is given.

EUROPEAN manufacturers, recognizing the fact that Diesel engines have come to stay, are preparing to meet the demand. Word has been received in San Francisco to the effect that the firm of Harlan & Wolf are scrapping their steam-turbine manufacturing plant on the Clyde to make room for new works for the manufacture of Diesel engines. A great deal of quiet preparation is going on in the United States along the same lines. In San Francisco two well known companies have already taken up the manufacture of this newest type of prime mover, and there is no doubt that others will soon follow. The marine and isolated power plant fields for this engine are especially attractive.

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Ditch Excavation on the Los Angeles Aqueduct

By O. W. PETERSON*

FOURTEEN miles north of Independence, Inyo county, California, the Los Angeles aqueduct obtains its chief source of supply from the Owens river by means of a concrete diversion dam and headworks. Through the Owens valley bottom, an earthen canal, really a straightened river channel, has been dredged for a distance of twenty-three miles. At mile 23, the aqueduct changes to a concrete lined canal. Here the Alabama hills start, and for fifteen miles to the south the line is well up on the steep face of these low old hills, with occasional detours around the steep fans of coarse boulders which are thrown out from the hill canyons. From the south end of the Alabama hills, the line follows around a series of debris fans, ranging in structure from loose desert soil to boulders of varying size more or less cemented. At mile 61 the Haiwee reservoir is reached. This reservoir is seven miles in length and has a capacity of 63,000 acre feet.

An interesting feature of the first sixty miles of the aqueduct is the fact that the old beach line of ancient Owens lake, which stood at an elevation of 3790 ft., 220 ft. above the present lake level, is closely followed by the constructed ditch. Along the Alabama hills particularly, the old beach line gravels are frequently encountered. As the gravels are of excellent range in size and of extreme cleanliness, they have been very convenient and economical for concreting. The first sixty miles of the aqueduct is designed for a capacity of 930 cu. ft. per second, so as to be of sufficient size to carry the normal flood flow of the Owens river, and other Sierra streams, to the Haiwee reservoir. From this storage basin, a uniform flow of 430 cu. ft. per second is carried, entirely in a covered conduit, to the head of the San Fernando valley where the various distributing lines start. Approximately two-thirds of the aqueduct, or a distance of 158 miles, has been excavated by dredge or with power shovels. As the dredged canal is only 23 miles in length it is realized how important a matter it was to obtain excavating machinery that would handle such a great amount of work in an expeditious and economical manner. Fortunately the long boom power shovel was early adopted for this work.

Three hydro-electric power plants had already been constructed in Owens valley by the Power Bureau of the Los Angeles aqueduct, and a power line had been built parallel to the aqueduct line for 150 miles to the south so as to facilitate the driving of tunnels and the operation of various kinds of construction equipment. Naturally, under these conditions, the employment of power shovels operated by electricity seemed the most attractive, for the power was very cheap as compared with fuel oil.

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being about one-fourth in cost, and even at that might be considered largely a book charge as the entire system was built with power to spare. As a result of this situation, several electric shovels as well as several steam shovels were purchased to start work. While it is not the purpose of this paper to enter into a special comparison of these two types of shovel, the comparison later given is a fair representation of the experience on the aqueduct.

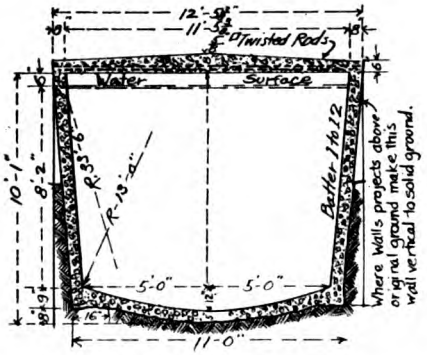

FIG. 1. MOJAVE DIVISION.

Hydraulic properties:

Slope	0.00035
Capacity	431
Velocity	4.59
Area	93.95
Wetted perimeter	26.65
Hydraulic radius	3.53
n	0.014
C	130.7

Construction quantities per lineal foot of conduit, normal section:

Excavation	4.23 cu. yd.
Concrete in conduit	0.536 " "
Concrete in cover	0.2033 " "
Steel in cover	13.75 lb.

On 98 miles of the aqueduct, special model 40 shovels with 26-ft. booms and ¾-yd. dippers have been used to excavate the section, shown in Fig. 1, for the concrete covered conduit. Most of this work has been easy digging in desert soil although some hard sidehill rock work and boulder excavation have also been done.

This paper is particularly concerned with the excavation of the 37 miles of the Olancha division. The section of this lined canal is excavated 12 ft. wide in the bottom, 36 ft. wide at the top, and 12 ft. deep on one-to-one slopes. The capacity of the completed canal is 930 cu. ft. per second. Fig. 2 shows the section built in the Alabama hills. It was decided that this section should be the most stable type of lined canal, of good hydraulic properties, which could be conveniently excavated with power shovels having 35-ft. booms, and probably be lined without the use of forms.

The canal is so situated that it would be entirely in cut, or where this was impossible, the upper wall should be below the natural ground-level, while the lower wall should not have over 3 ft. of backfill, except on steep sidehills where the top cut is as high as 70 ft., the lower wall is built against 3 to 5 ft. of backfill. At all places it is planned to have the canal safe as an unlined canal and then add the lining for safety and to provide a smooth and water-tight surface.

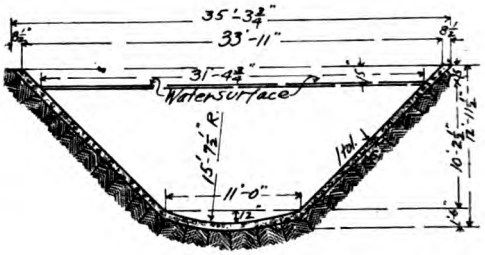

FIG. 2. OLANCHA CONDUIT, COTTONWOOD CREEK TO HAIWEE RESERVOIR.

Hydraulic properties, normal section:

S = 0.00015	n = 0.014
A = 223.57	C = 139.2
W.P. = 39.91	V = 4.03
R = 5.60	Q = 901

Construction quantities per lineal foot, normal section:

Excavation	10.57 cu. yd.
Concrete	0.813 " "

The materials excavated can best be divided into four classes: first, the loose desert soil (a sandy loam); sec-

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ond, boulders of medium size (up to 5 ft. diameter) more or less cemented; third, extremely large boulders, loose or cemented; fourth, cemented gravel or solid rock. All these classifications are encountered separately and in combination and either in level cutting or on the steep slopes. The yardage per foot ranges from 8½ yd. minimum to as high as 30 yd. on the sidehill. Long-boom power shovels are used to excavate the ditch. Two of these are model 60 Marion steamers of standard gauge with 35-ft. booms and 1½-yd. dipper. A third is of the same type with 38-ft. boom, and the fourth is a special model 60 Marion electric with 40-ft. boom and 1½-yd. dipper. The steamers have special bank jacks designed for the small space allowed in a ditch with a 12-ft. bottom and with 1 to 1 side slopes. These jacks are operated by hand. The electric shovel has an 8-ft. gauge, high A frame, and telescoping bank jacks operated by separate 10-hp. motors mounted over the jacks. This shovel is operated by a 2200-volt 100-hp. motor. The dipper handle is operated by a friction clutch.

In desert soil, the costs are quite easy to account for. Each of the two shifts on the steam-shovels require the following crews:

1 operator	at	$155.00	per month
1 craneman	"	115.00	" "
1 fireman	"	80.00	" "
4 pitmen	"	2.50	" day
4 pitmen	"	2.25	" "

These men work six days per week of eight hours each and repair the shovel on Sunday. The costs shown do not include board. All meals are furnished by a mess contractor to the men at 30c. each. The total cost for labor is $955 per month a shift, or $1910 for two shifts. A night watchman on the shovel at $75 per month brings the total labor cost to $1985 per month for two shifts.

During the first year, freight on fuel oil was $11.76 per ton or $1.96 per barrel. This was later reduced to $8.52 per ton or $1.42 per barrel. The average price of fuel oil in the vicinity of Bakersfield has been 45c. per barrel, and so the average cost delivered to the shovels has been about $2.25 per barrel. Each shift uses 10 barrels, a total of 20 barrels per day. With an average of 48 shifts worked in one month the total oil consumption is 480 barrels, which at $2.25 per barrel amounts to $1080. Repairs of various kinds amount to $175 per month. Other small charges for lights, various small items, etc. bring the total costs to $3500 per month. Thus far, the steam shovels in easy desert soil, excavating 35,000 yd. per month, labor costs 6c. per yard, fuel oil 3c., repairs about ½c., and miscellaneous small charges ½c., making a total of 10c. per yd. for direct construction costs.

On the same class of work, with first class electric shovel crews, the progress is 2000 to 3000 ft. per month with an average of 2500 ft. and about 23,000 yd. output. The labor costs amount to about $1700 per month, as a night watchman is not needed, also one or two less pitmen on each shift as compared with the steamers. A typical month shows 50 shifts, 11,370 kw. hour consumed at the rate of 28.4 kw. per hour during operation at a cost of $0.017 per kw. hour. The total cost for the month was $191.78. Repairs amount to about $200 per month. Miscellaneous small expenses are about $150 more, making a total of $2241.78 or practically 10c. per yd. for material excavated. Labor costs $0.074 per yd., power $0.0073, repairs $0.0087, and miscellaneous items $0.006.

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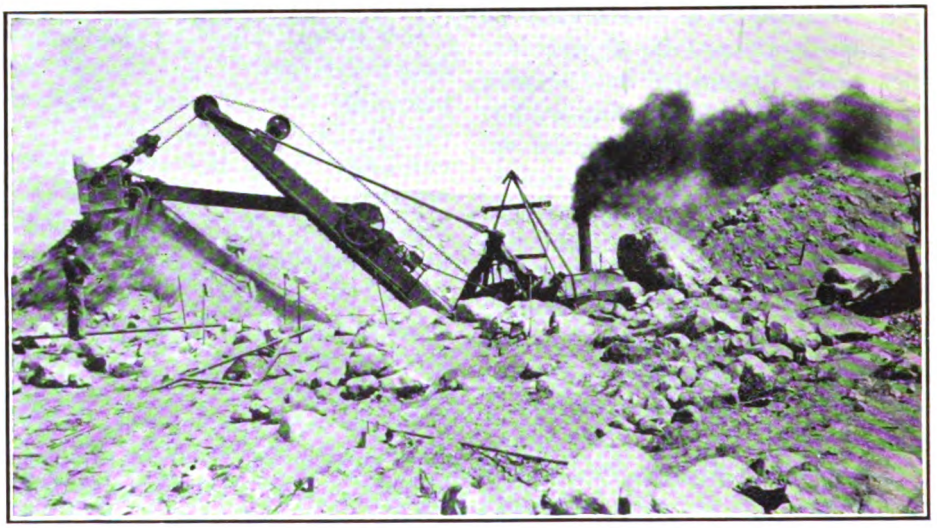
In the second class of work in boulders up to about 5 ft. diameter, more or less cemented with a hard indurated clay or gravel, the steamers with little or no shooting ahead of the shovels, except to bulldoze some of the larger boulders, obtain 2600 ft. progress per month with about 22,000 yd. output. Due to the powder used, and the increased repairs, the costs for the month for two shifts is: labor $2000, fuel oil $1000, repairs $350, powder, $400, and miscellaneous items $200; a total of $3960 or an average of 18c. per yard.



BOULDER EXCAVATION AT OLANCHA, LONG-BOOM SHOVEL.

The electric shovel cannot dig such material without having it shot up in advance at a cost of 11.4c. per yard. Holes are put down 12 to 15 ft. apart and about 2 ft. below grade, and are shot with about 110 lb. of black powder; 1600 ft. of progress with 14,000 yd. output is an average month's work. Delays and breakdowns become more serious and frequent. It has been found better to plug a shallow hole in boulders ahead of this shovel rather than bulldoze them, as the shovel suffers too much from heavy shooting. Here the costs are: labor $1700, power $130, repairs $250, powder to break boulders in the pit $100, miscellaneous small expenses $200, a total of $2380. Add to this $1600 for drilling ahead of the shovel and the total excavation cost is $3980, with an average of 28c. per yard. This is 10c. per yard more than it costs with the steamers. Here especially the smaller progress of the electric shovel seriously effects the cost of trimmings and concreting the ditch.

No attempt is made to use the electric shovel in the more difficult classes of work. In the heaviest boulders, in level cutting, it is very difficult to make more than an average of 1800 ft. per month with the steamers on a two-shift basis. At places, granite boulders 10 to 20 and even 30 ft. in diameter are encountered in large numbers. A 3-in. Sullivan drill, operated by steam from the shovel, is used in the pit to put holes in these boulders. Of course all boulders possible are bulldozed with large quantities of dynamite. Labor costs are higher, as two drill men and

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a tool sharpener are added to the usual crew. There is not much fuel oil used, for the reason that sometimes the shovel can dig only an hour or two per shift. The total expenses are: labor, $2300; fuel oil, $850; repairs, $450; powder, $1000; miscellaneous items, $200. A total of $4800. The unit yardage cost for 15,000 yards is 32 cents.

The next condition, and this by far the most difficult class of material to excavate, is where enormous boulders are massed into fairly solid formation on a steep sidehill with cuts of 50 to 70 ft. on the upper side. There are layers of cemented gravel in with the boulders, with enough loose material at places to cause the drill holes to ravel badly. Machine drills could not be used, for the reason that the holes ravel too much and the drill would constantly stick. Two rows of deep holes have to be put down, one along the inside edge of the bottom of the ditch, about 4 ft. below grade and the second about half way up the slope. The former holes are 24 ft. in depth, the latter about 16 to 18 feet. Two to three days are required by three men to drill, or churn down each hole. The deep holes are then sprung to hold about 450 lb. of 5% Judson powder and the shallow ones to hold from 250 to 300 pounds. As each of these sets of holes loosens about 350 yards of material, the cost amounts to about 25c. per yard.

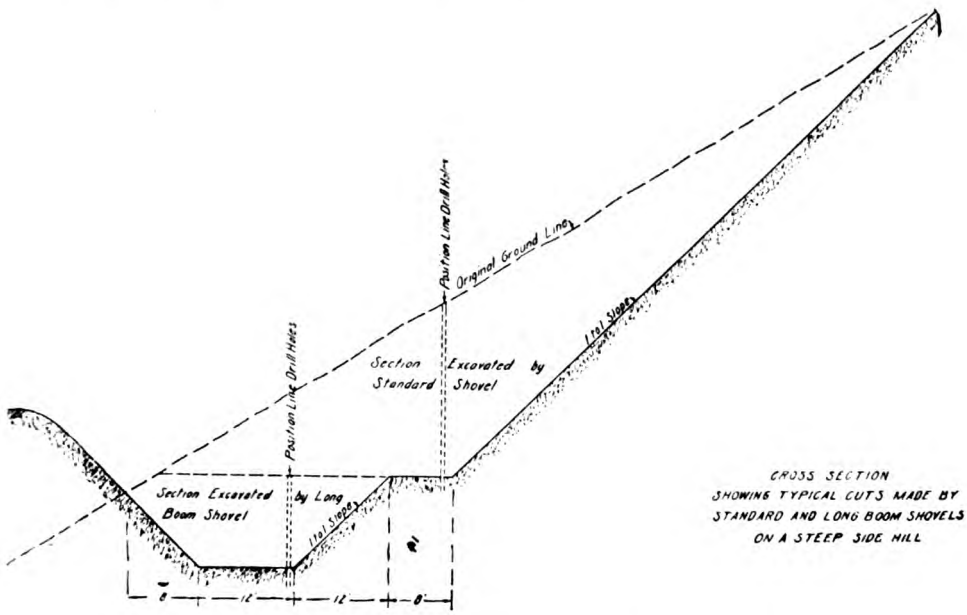

FIG. 3. METHOD OF OPERATING TWO-SHOVEL PLAN ON SIDEHILL CUTTING.

It was realized that a shovel with a 35-ft. boom which could reach up only 22 ft. and out from 25 to 30 ft. could not handle a 70-ft. cut on the upper slope. Some work up to 50 ft. was done with one shovel but it was extremely slow as the top 20 ft. had to be barred down to the shovel. A model 40 Marion steamer, which was available, was put in ahead of the ditch shovel to handle the top cut. This shovel had a boom 25 ft. long, standard jacks, and a ¾-yd. dipper. It was planned to take down about 40 ft. of cut with this, leav-

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ing 20 to 30 ft. for the shovel in the ditch. It was soon found that this shovel was a benefit, but not nearly as much as a standard model 60 shovel would be. However it was used to finish up the heavy cutting through the boulders. About 100 ft. progress with 27,000 yards output was obtained by the two shovels through the heaviest boulders. The advance drilling had to be done extremely well, but an enormous amount of bulldozing was required to break up the individual boulders. Repairs naturally were very heavy. Advance drilling and shooting costs 25c. per cubic yard or $6.75 per foot. The cost for operating the two shovels was: labor, $3600; fuel oil, $1300; powder for bulldozing, $1000; repairs, $600; and miscellaneous charges, $300. A total for the month of $6800. The unit cost for excavation was 25c. per yard or $6.80 per lineal foot, making a total for all drilling, shooting, and excavation of $13.55 per foot, or 50c. per yard. This extreme condition did not prevail over more than a few thousand feet. In fact the highest cost on a single mile was $9.25 per foot or 45c. per yard for excavation.

For the first 6 miles in the Alabama hills, the ditch to a considerable extent is built in a formation which ranges from a solid rock cut to one which has soil, boulders, cemented gravel and broken angular rock, separately or with the last two mentioned in combination, overlying but a foot or two of solid rock. The rock of the Alabama hills is an extremely hard andesite. Pits are dug from 12 to 100 ft. apart to prospect thoroughly ahead of the shovel, and except where there is only a foot or two of solid rock above sub-grade, drilling and shooting is done to break it up. In normal cutting, this can be done very easily with ordinary methods. In some of the work on the sidehill, with a rock cut 50 ft. deep on the upper slope, one shovel excavated the section. The line had been drilled in advance with a double row of holes and shot heavily.

Prospecting, drilling, and shooting costs 25c. to 40c. per yard of solid rock. The excavation costs 18c. to 30c. per yard, depending on how well the shooting had been done and how much delay there was in sloping down the portion of the hillside the shovel could not reach. In rock work, every effort has been made to thoroughly shoot up the section in advance of the shovel, and this should extend to such a depth that the bottom and toe of the slopes are entirely broken. Too light shooting also makes the rock seamy and is far worse than a waste of money.

As explained previously the use of the two-shovel plan, Fig. 3, on heavy sidehill cutting should be used. But to get the best results the top shovel must be of ample capacity and so, although but a few months' work remained, a model 60 Marion steamer with 25-ft. boom and 2½-yard dipper was purchased. It was pointed out that this shovel would do fully four times as much work as the long boom model 40 with the ¾-yard dipper and at the same daily cost. While the small shovel used only 7 barrels of oil per shift the repairs for it in heavy work were so much greater than on a large shovel that it cost just as much as the larger model to operate. A dipper handle 2 ft. longer than the standard was placed on the new shovel to give it a greater working range. This shovel takes down a bench about 40 ft. high on the upper side, with some aid of the pit crew sloping at the top, leaving only a level cut of 12 ft. for the ditch shovel; besides, it leaves a 6-ft. berm between the ditch and the hill slope.

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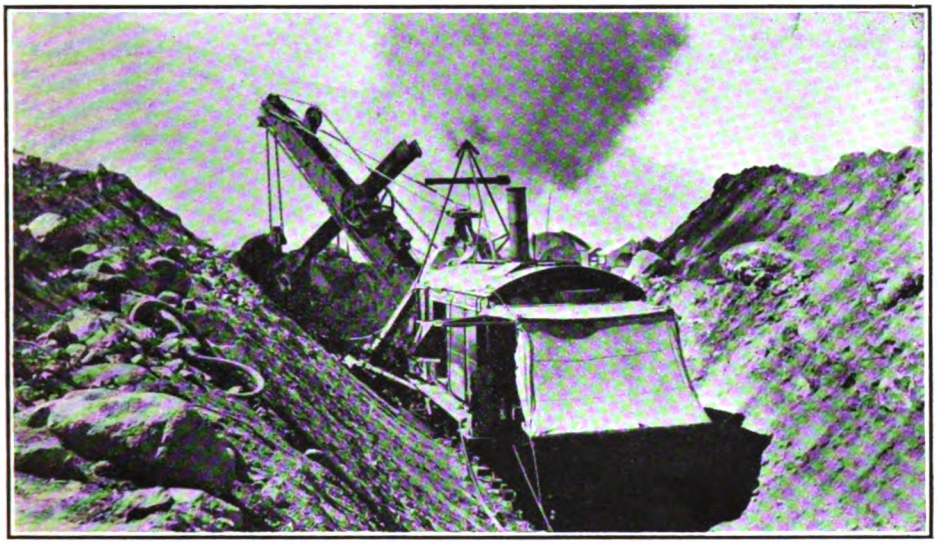
There is, of course, a great deal of difference between excavating a sidehill bench cut with a standard-boom shovel and digging a ditch with a long-boom shovel. In the first case, only enough lift of the dipper is required to fill it and then it is swung quickly to dump. In the second case, the dipper usually has to be raised from 18 to 20 ft. each time, then swung slowly out and back with time to lower again into the pit.



REAR VIEW LONG-BOOM SHOVEL, SHOWING TYPE OF JACKS USED.

Not only is the long-boom shovel much slower in action, but the dipper used is only about one-half the capacity of that on the standard shovel. An actual test shows the 35-ft. boom shovel with 1½-yard dipper when digging broken rock takes out 2¾ buckets per minute—4.125 cu. yd. per minute. The 25-ft. boom (standard) shovel with 2½-yd. dipper takes out 4 dippers per minute—10 cubic yards. Thus during time actually spent in digging, the output of the standard shovel is 2.4 times as great as the long-boom shovel in the ditch.

Behind the first shovel, there follows the prospecting and drilling gang to find and shoot all solid rock that could not be handled economically before the standard shovel had passed. Test pits are put down about 25 ft. apart to discover any ledge of solid rock, and, when any is found it is more thoroughly prospected and shot. When but 1 or 2 ft. of rock stands above sub-grade no effort is made to work through 10 ft. of loose covering to drill it, but it is left to be drilled and shot in the pit after the ditch shovel has stripped the covering. A long-boom shovel can strip about 14 ft. ahead. This section is then drilled by machine and shot. In cemented gravel the drilling is much easier. This formation does not require as heavy shooting, and when found in the base of the pit or up in the face, it can often be bulldozed. But as far as possible nothing solid is left for the ditch shovel. Owing to the extreme variation in the proportion of loose to solid rock it is difficult, in the absence of measured yardage of each separately, to give more than an estimate

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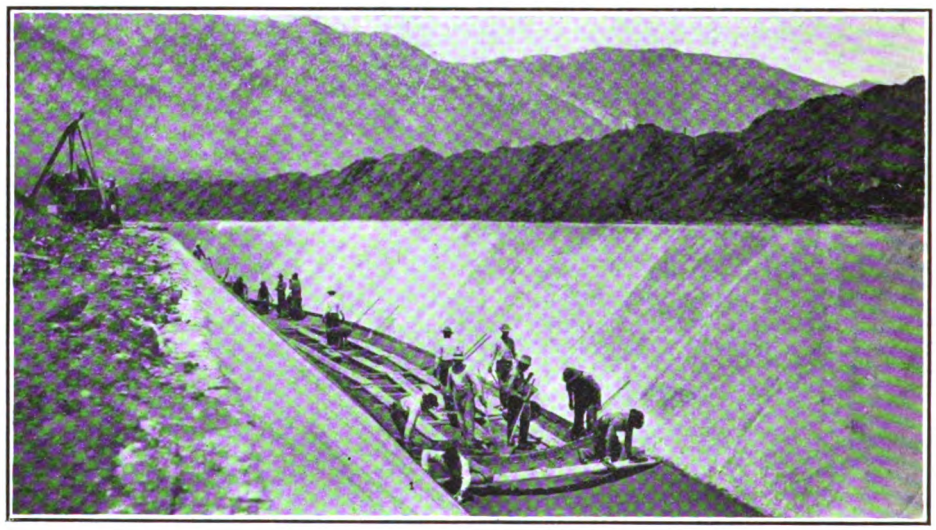
of the segregated costs. Prospecting for solid rock can be more conveniently and thoroughly done when the section is handled in two cuts and the drilling itself can likewise be done to better advantage and at less cost. Drilling and shooting is done for 25c. to 35c. per yard, including prospecting for the rock. Excavation costs 6c. per yard for the standard shovel on the bench and about 22c. for the long-boom shovel in the ditch. This shovel, at best, occasionally is delayed on account of outcrops of ledges just above sub-grade.

To summarize, one shovel in a cut of 22 yd. per foot with 20% solid rock can make only 800 ft. of progress per month at a cost of about $5.50 per foot, or 25c. per yard, for the shovel in addition to the cost of $2.50 per foot, 55c. per yard, for drilling and shooting all solid rock. With two shovels, fully 2000 ft. per month progress can be made at a cost of $2.85 per foot, 13c. per yard, for excavation, and $1.80 per foot, 40c. per yard, for prospecting, drilling, and shooting the solid rock, making a total of $4.65 per foot of ditch.

There has not been a great deal of excavation in cemented gravel exclusively, but a considerable amount of drilling and shooting in this formation has already been done. The costs are about 20c. per yard for drilling and shooting such material. It drills faster and does not require as much or as strong powder as solid rock. Excavation of cemented gravel that has been shot up is about the same as broken stone or about 25% more than earth, depending, of course, on how well the shooting has been done.



PLACING CONCRETE BOTTOM LINING.

When sufficient water under pressure can be obtained conveniently, such materials as earth, broken rock with earth, or cemented gravel thoroughly shot up, can be washed off a hillside sufficiently to make it unnecessary to use a standard shovel to take off the top bench. A hillside is being handled in this manner at the north end of the Alabama hills.

Direct construction costs in the camps only have been considered. In addition such auxiliary charges against excavation as a contractor would have are as follows:

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TYPE OF SHOVEL	CHARACTER OF GROUND	MONTHLY PROGRESS	MONTHLY YARDAGE	PROSPECTING DRILLING & SHOOTING PER CUBIC YARD	LABOR	FUEL OIL OR POWER	POWER SHOVEL OPERATION: REPAIRS	POWER SHOVEL OPERATION: POWER USED IN PIT	MISC'L.	TOTAL	AVERAGE TOTAL COST DRILLING AND EXCAVATING	EQUIPMENT	ROADS	AUXILIARY CHARGES: WATER SUPPLY	AUXILIARY CHARGES: DIVISION ADMINISTRATION SUPERINTENDENCE HOUSING	MISC'L SMALL ITEMS	TOTAL	TOTAL CU. YD.
Model 60 Marion Steamer - 35 or 38 Ft. Boom 1½ yd. dipper.	Desert Soil (Sandy Loam)	4000	35000		.06	.03	.005		.005	.10	.10	005		.003	.005	.001	.014	114
Model 60 Marion Special Elect. 40 ft. Boom. 1½ yd. dipper.	Do.	2500'	23000		.074	.0073	.0087		.006	.096	.096	.01		.001	008	.001	.020	.116
Model 60 Marion Steamer-35 or 38 Ft. Boom. 1½ yd. dipper.	Boulders to 5' diameter. More or Less Cemented	2600'	22000		.091	.0455	.016	.018	.009	.18	.18	.008	.01	.004	008	.001	031	.211
Model 60 Marion Special Elect. 40 ft Boom. 1½ yd. dipper.	Do.	1600'	14000	.114	.121	.0093	.0178	0071	.014	.17	28	.018		.001	014	002	.035	.315
Model 60 Marion Steamer 35 or 38 Ft. Boom 1½ yd. Dipper	Boulders. Very Large	1800'	15000		.152	.057	.03	.067	.013	.32	32	012	.01	.004	014	.002	.042	.362
Model 60 Marion Steamer 35 Foot Boom 1½ yd dipper Assisted by Model 40 Marion Steamer 25 ft Boom ¾ yd. dipper On Top Cut	Very Large Boulders in Solid Formation on Side hill. Top cut 70 feet	1000'	27000	.25	.133	.048	.02	037	.011	.25	50	012	.015	.005	.020	.003	.055	.555
Model 60 Marion Steamer 35 Ft Boom 1½ yd. dipper	Loose to 20% Solid Rock. Side Hill	800'	17600	55*	.14	.06	.02	02	.01	.25	355†	.012	.015	.005	025	.003	.06	.415
Model 60 Marion Steamer 35 Foot Boom 1½ yd dipper Assisted by Model 61 Standard Marion Steamer 25 ft Boom. 2½ yd. dipper.	Do.	2000'	44000	40*	.082	.035	.01	005	.008	.14	.21†	.012	.015	.005	.01	.003	.045	.255

*Applies to the solid rock portion of section. Equals 4.4 cu. yd.
†Cost of drilling, shooting and excavating section containing 20% solid rock. Solid rock portion would cost approx. $0.80 and $0.54 per cu. yd. by the respective methods.

UNIT COSTS FOR DITCH EXCAVATION BY POWER SHOVELS IN VARIOUS CLASSES OF MATERIAL. PERFORMANCE WITH TWO EIGHT-HOUR SHIFTS, SIX DAYS PER WEEK.

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Excavation equipment, per lineal foot of ditch	$0.15
Roads, per lineal foot of ditch	0.01
Water supply, per lineal foot of ditch	0.04
Administration, including superintendence and housing	0.10
Other small charges	0.02
Total	$0.32

This overhead expense of 32c. per lineal foot of ditch for excavation amounts to an average of 2½c. per yard for all work done. In easy digging it would be about 1½c. per yard while in the heavier work it would be 3½c. per yard. It increases the direct construction costs an average of 10 per cent.

Experience on this work has suggested some improvements in the shovel equipment. As it is a difficult matter to have cuts always normal, the ditch shovels at times have more dirt than they can conveniently dispose of. If water is available, and the ground slope sufficient, the spoil banks can be most cheaply washed away so as to provide sufficient room for the shovel to dump. But where there is no water, a great deal can be done by shovels in pushing out the dirt with the dipper. This is hard on the crane engines and also cuts down the progress of the shovel. To avoid such a practice as much as possible, the shovel booms should be sufficiently long for the work expected of the shovel. The increase of only 3 ft. in the length of the last boom purchased (38 ft.) makes that shovel fully 5% more efficient than the shovels with the 35-ft. booms. There is no appreciable difference in the swinging of this 38-ft. boom compared with those 35 ft. in length. Of course there is a limit to the length of boom any one shovel can stand. Another improvement which would add all of 10% to the efficiency of the steam shovels in easy digging, but less than that amount in harder and slower digging, would be to have them equipped with a high 'A' frame and telescoping bank jacks operated preferably by steam. It takes at least five minutes to loosen and set the jacks by hand on the types used on the steamers and this time may be easily increased to ten minutes. With the telescoping type, but a minute or two is required. Then, too, an 8-ft. track-gauge should be used, and this with the telescoping jacks would insure thorough stability of the shovel against turning over.

As regards the shovel used to take off the top bench cut, this, too, could have a special 30-ft. boom and 2-yd. dipper and probably be greatly improved for higher cutting. This shovel of course would use standard jacks. The use of special booms, dippers, or jacks in no way changes the shovel itself as they can be put on the standard models, and the increased costs of special equipment is a small consideration where there is sufficient work. But it is most important to adopt as few sizes of shovels as possible, preferably one size, and especially one make of shovel. By adopting such a plan, the number of extra repair parts carried for a job can be kept at a minimum and a much smaller shop-gang can handle the repair work. Such a policy is not only economical, but most convenient.

The work on this division, as on the aqueduct generally, has been done directly by the aqueduct organization by the use of day labor. William Mulholland is chief engineer and J. B. Lippincott is assistant chief engineer on the Los Angeles aqueduct. John Anderson is an expert steam shovel man who has acted in an advisory capacity on all power shovel work on the aqueduct. I am division engineer on the thirty-seven miles comprising the Olancha division.

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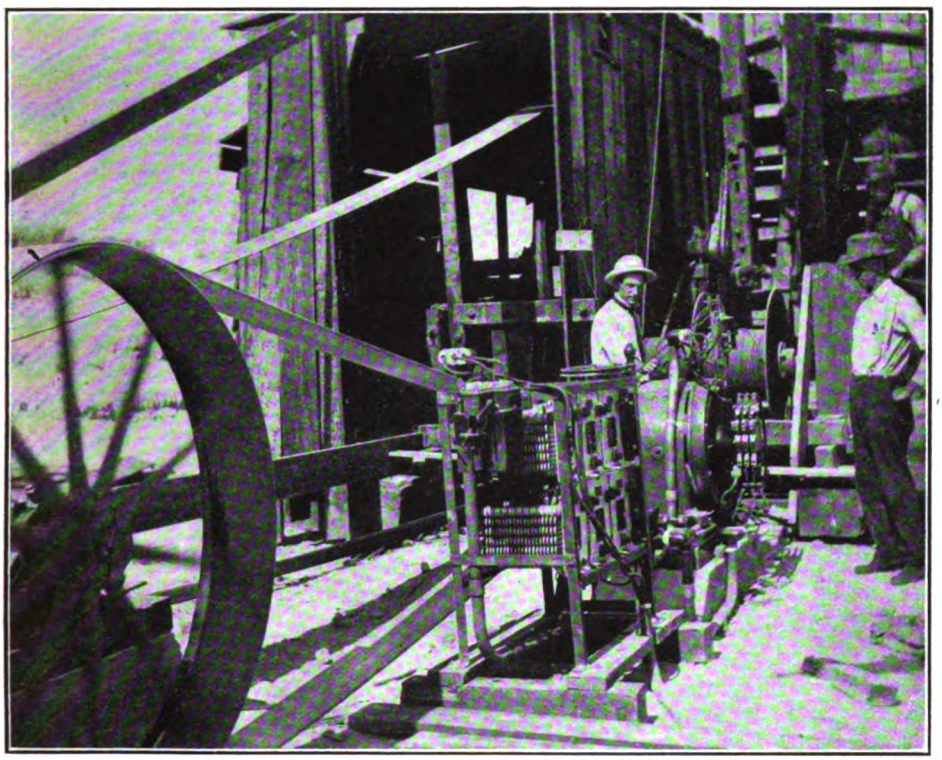
Electric Motors for Oilfield Service

By L. A. SOMERS*

ELECTRIC motors for oilfield service were first introduced in the oilfields near Los Angeles, about ten or twelve years ago, by the Westinghouse Electric & Manufacturing Company. These motors were of the direct-current, shunt-wound type, but it was found that they were entirely unsuitable for the work attempted to be performed, namely, the drilling of oil wells. The power supply also was unsatisfactory, and therefore the employment of electric motors for drilling wells in this section of the country was abandoned.

The next experiment was made on the lease of the Associated Oil Company in the Kern River fields near Bakersfield, about eight years ago. A variable speed motor, wound for 440 volts, 60 cycles, 3 phase, was used, and a well was drilled successfully with this motor, but again it was found that the power supply was unsatisfactory. An attempt was also



30-HP. VARIABLE SPEED WESTINGHOUSE OIL WELL MOTOR AT CHANSLOR-CANFIELD MIDWAY OIL CO. LEASE, TAFT, CALIFORNIA.

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made with one size of motor to drill, pump, and clean wells, which proved to be expensive and inefficient, inasmuch as the motor required for drilling a well proved to be entirely too large for pumping duty.

Nothing more was done toward the application of the electric drive to oil-well service in California until the fall of 1909, when the Westinghouse Electric & Manufacturing Co. brought out a 30-hp. intermittent rating, phase-wound, variable-speed motor, wound for 10 poles, 440 volts, 60 cycles, 3 phase. This motor was installed on the Sherman lease near Los Angeles, and successfully pumped, pulled, and cleaned the well at which it was installed at a very low cost for electric current. This motor was furnished with the so-called 'star-delta' arrangement, and by means of a small three-pole double-throw switch mounted on the frame of the motor, it could be efficiently operated in 'star' for pumping service, and also in 'delta' when the heavy duty of pulling and cleaning a well had to be taken care of. The continuous rating of this motor, when 'star' connected was 10 hp., and when 'delta' connected, 30 hp. for approximately one-half hour.

The depth of this well was approximately 2000 ft., and by means of the 'star-delta' arrangement, the motor could be operated efficiently, either at the low pumping duty, or the heavy duty required when pulling or cleaning the well. All the other installations in the various fields of California have followed from the successful results obtained with this motor on the Sherman lease, so that at the present time something like 500 motors of various types are in successful operation in the oilfields of California.

After the work of the first induction motor was successfully demonstrated by experiment on the Sherman lease, the first permanent installation in California was made on the lease of the Good Luck Oil Company, in Coalinga. Three Westinghouse pumping motors were installed in July 1910, and these motors have now been in use for over two years, without costing one cent for repairs.

The next permanent installation was made on the lease of the Chanslor-Canfield-Midway Oil Co. in January 1911, and after this company had tested these motors out for three months on power supplied by its own plant, decided to completely electrify its lease, and has since been purchasing motors with that end in view. Nearly 115 Westinghouse motors are installed on this lease, and the results obtained have been very gratifying to the Chanslor-Canfield-Midway Oil Company, from every point of view. It is noteworthy that this company, after operating the first two experimental motors for six months on power from its own plant, decided that it was preferable to use central-station power, and on the completion of the lines of the San Joaquin Light & Power Corporation in the Midway fields in the summer of 1911, made a contract with that corporation for central-station power, and this arrangement has been very satisfactory, both from the standpoint of continuity of service and also the cost of current.

In the majority of cases, the continuous rating of the motors so far installed, has been 10 hp., but some have been installed with a continuous rating as low as 5 hp. and as high as 15 hp. The continuous rating of the motor depends upon the condition and depth of the well, the gravity of the oil, the amount of oil and sand pumped, and the speed at which the band wheel re-

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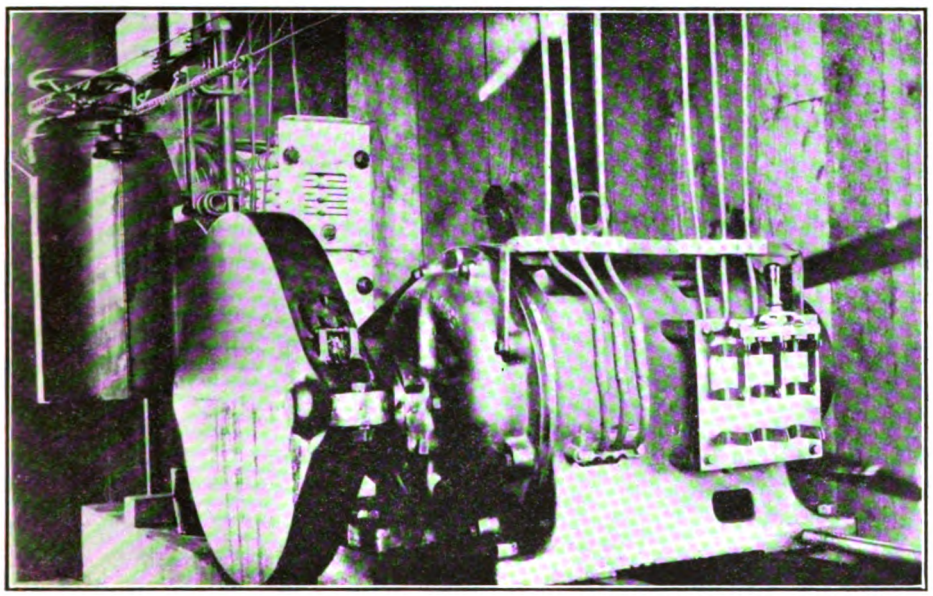
volves, which determines the number of strokes per minute of the pump.

The only way the correct size of motor can be determined is by actual experimental work, as it is found that the requirements differ in each field, owing to the varying conditions which exist in different districts in the oilfields of California. Up to the present time, alternating current motors only have been used, as they are most suitable for the work. These have been of two types: namely, the squirrel cage, constant speed, and the phase wound variable speed types of induction motors. These two types, or classes, may be further subdivided as follows: First, squirrel cage, single-speed; second, squirrel cage, two-speed; third, phase wound, single-speed; and fourth, phase wound, two-speed.

The latter type of motor is now being introduced and is still in an experimental state. Just what type of motor should be used will depend on the conditions to be met with in each field, but the following comparisons between the squirrel cage and variable speed, phase-wound motors may assist in a solution of this problem.

Two-Speed Squirrel Cage Motor, Versus One-Speed, Wound Secondary Motor for Pumping and Maintaining Wells

Both of the above types of motors have a number of advantages and dis-



30-HP. WESTINGHOUSE BACK-GEARED MOTOR AT KERN RIVER OILFIELDS LEASE OF CALIFORNIA LIMITED, OIL CITY, CALIFORNIA.

advantages for oilfield work, and the type of motor to be selected should be chosen as before stated, only after considering the conditions which exist in each field.

Advantages of a Wound Secondary Motor

The wound secondary motor allows a very fine speed regulation anywhere between its rated speed and 50% of rated speed. The starting torque of a wound secondary motor can be adjusted within

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certain limits. Therefore, it is possible to avoid sudden mechanical and electrical shocks on all parts of the installation, if the controller is properly handled. Whether or not this advantage is of practical importance depends upon whether the operator uses sufficient care in the handling of the motor. It is desirable to have a certain drop in speed when the pumping rods are lifted, and the amount of this drop and the best working conditions can be easily regulated with the wound secondary motor after it is installed.

Disadvantages of a Wound Secondary Motor

In a wound secondary motor, the secondary as well as the primary element is subject to burnouts, and the cost of repair of such a motor is greater than that of a squirrel cage motor. A wound secondary motor requires slip rings and brushes, which in the case of gaseous wells might have to be avoided, since of course the rings and brushes would be liable to spark if they were not kept in good condition. A wound secondary motor works economically only at its highest speed, and below this, each per cent of speed reduction means approximately 1% reduction in efficiency. The ability to vary the power of a single-speed, wound secondary motor is confined within smaller limits than that of the two-speed squirrel cage motor. The single-speed motor can develop about three times its continuous rating for one-half hour if it is connected in 'delta.' In a two-speed, squirrel cage motor of the same size, the continuous as well as the half-hour rating can be doubled if the motor is run at the higher speed. Some of the advantages of the two-speed, squirrel cage motor as compared with the single-speed, phase-wound, variable-speed motor are as follows: First, simplicity of motor and ease of repair; second, absence of slip rings and elimination of fire danger; third, two economical speeds; fourth, greater variation of power; fifth, no change of pulley is required if it is necessary to pull or clean the well.

The disadvantages of a two-speed squirrel cage motor are: First, the motor can be operated with two speeds only; second, the starting torque cannot be adjusted for more than four values; third, the pumping speed of the well cannot be adjusted without changing the pulleys. However, it will be noted that on a number of leases where these two-speed squirrel cage motors have been installed, they have given absolutely satisfactory service for both pumping and pulling duty, and on account of their lower first cost, great mechanical strength, ruggedness, simplicity, and ease of repair, have been preferred by a number of operators to the phase-wound, variable speed motor.

In a great many cases, the idea that it is necessary to have a variable speed motor for pumping service in the oil-fields, is due to the fact that the steam pressure in the boilers and steam lines which supply the steam for pumping service, varies greatly. When the pumper makes his rounds, he finds it necessary to vary the speed of his engine, for the reason that he is trying to get the most efficient pumping speed. On most leases, after the wells have attained a certain age, it is found that there is a definite speed at which to pump the well, which produces the highest efficiency—that is to say, the speed at which more oil can be produced than at any other speed. Of course where this condition exists, it means that a two-speed squirrel-cage motor can successfully be used. In some

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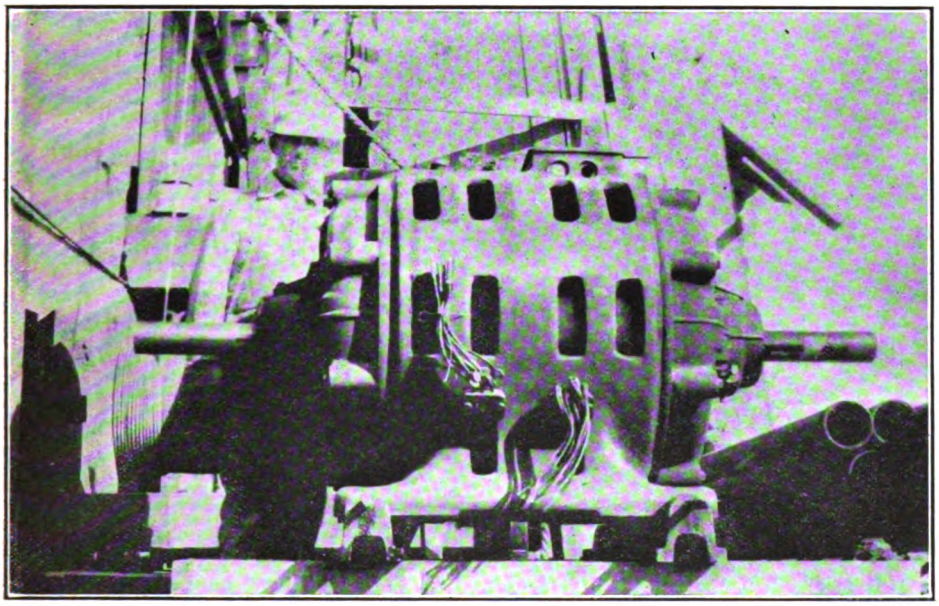
parts of the fields, it has been found that the ordinary single-speed squirrel-cage motor can be used and where conditions permit of the installation of such a motor, the results are very gratifying, because exactly the right size of motor can be used for pumping, with the result that highest efficiency can be attained, together with the lowest possible cost for the total installation.

Single-speed squirrel-cage motors are also in successful operation in the Kern fields on the leases of the Associated Oil Co. and the Kern Trading & Oil Co., operating pumping jacks. The latter company has one motor-driven jack pumping twenty-two wells at a cost of approximately six dollars per day. This company is now putting motor-driven pumping jacks on all its wells that can be so operated in this field. Where such installations have been made and it is necessary to clean the wells more or less frequently, a portable cleaning rig should be used. This consists of a variable speed, phase-wound motor, mounted on a truck, which can be easily hauled to any well on leases where the single-speed motor is used. On such leases where the wells are troublesome and are 'sanding up' continually, the phase-wound, variable-speed motor is more convenient, and gives better results. For wells of this type, a phase-wound, variable-speed motor should therefore be used.



TWO-SPEED SQUIRREL-CAGE WESTINGHOUSE OIL WELL MOTOR AT KERN TRADING & OIL CO. LEASE NEAR COALINGA.

In the majority of cases, all the motors sold to date have been belted to an intermediate countershaft. This counter shaft is connected by means of a belt to the band wheel from which the power is transmitted to the pump rod by means of a walking beam. In a few cases back-geared motors have been used and the intermediate counter shaft done away with. However, the most satisfactory type of motor has proved to be the belted type, and this type is now generally being used.

As compared with operating oil wells

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by steam, it has been proved conclusively in the last two years that the electric motor is far more efficient; has greater overload capacity; requires less attention, and is far more economical in every way than the steam engine. It is impossible for the electric motor to run away and distribute itself all over the oilfields, as sometimes happens to steam engines, and on account of the regular speed of the electric motor, the production is sometimes increased as much as 10% as compared with operation by steam.

On most of the leases where electric motors have been substituted for steam engines, the saving in the cost of operation has been approximately 50%. To date there has been no opportunity of making a direct comparison with wells operating by gas engine, but it is known that the majority of wells in the Midway fields, for instance, operate at a less cost per day per well for electricity than is the case with gas engines, where I understand that a fixed minimum charge is made to the oil well operators regardless of the amount of gas used. This does not take into consideration the extremely high cost of maintenance of the gas engine as compared with the very low cost of maintenance of the motor.

Since the perfection and development of the electric motor for pumping and cleaning oil wells, a successful drilling motor has been used, and it has been found that the phase-wound variable-speed type of induction motor is most suitable for this work. So far, motors varying in size from 35 to 60 hp. have been used, and the proper size of motor, for any locality and depth of well can only be determined after considerable experimental work in the ground. All of these drilling motors are wound to operate at 440 volts, 60 cycles, 3 phase. Various speeds have been used—that is to say, motors operating at from 514 to 900 r.p.m. have been installed with successful results.

The first successful drilling motor was installed by the Westinghouse Electric & Manufacturing Co., in the Whittier fields near Los Angeles, on the lease of the Central Oil Co. The next successful installation was made by the same company on the lease of the Chanslor-Canfield-Midway Oil Co., near Taft, Kern county. A hole, 940 ft. in depth, was drilled at a total cost of $57.70 for electric current. Since that date, a number of wells have been drilled in the Midway and Belridge fields successfully and at a very low cost. In some cases, the cost of electric current has not been as great as the cost of water formerly used when drilling these wells by steam.

In selecting a drilling motor, not only should the right capacity be determined but care should be taken that the motor have the proper fly-wheel effect and slip. This latter point is a very important one, because when a drilling bit is dropped, the motor should speed up and the rope should drop faster than the bit. In other words, the characteristics of the motor should be something like those of the series-wound direct-current motor. Power is transmitted to the band wheel by means of a 3-speed drilling gear, consisting of two sets of sliding gears, the gears meshing alternately. The gears run in oil and are covered by a dust-proof case, mounted in such a way that the interior is easily accessible. With this 3-speed drilling gear, a high, medium, and low speed is obtained as well as any torque necessary, which is sometimes an advantage in drilling deep wells. Sometimes the casing or the tool becomes stuck, and an enormous torque is required in order to remove it.

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Motor-Driven Pipe-Line Pumps and Sump Pumps

In order to be able to operate a lease entirely by means of electric drive, it is of course necessary to drive the sump pumps and the pipe-line pumps by means of electric motors. This can be done by the use of a rotary pump which can be direct driven by an electric motor. This pump is balanced at all pressures, and can be built for pressures up to 2000 lb. per square inch. The pump can be built for any capacity, and works as well on water as on oil. Thus, it will be seen that all the operations necessary to operate a lease by electric drive—that is to say, drilling the well, cleaning the well, pumping the well, and moving the oil after pumping, can be efficiently and successfully done by means of the electric motor.

For the benefit of those who are not very familiar with operations in the oilfields, it might be well to describe the different duties to be performed by an oil well motor, as follows:

Drilling.—In order to drill a well, a heavy steel bit is raised by means of a wire rope and dropped on the ground beneath. The operation is somewhat similar to that of a pile driver. In addition, however, to the hammering effect of the pile driver, the steel bit also has a cutting effect. By this operation the sands which contain the oil are finally reached. As the work proceeds, circulating water is introduced into the hole made by the bit, and after the drill has made some progress it is necessary to bail the well. The bit is removed from the wire rope, the bailer is substituted and is lowered into the hole. When the bailer is filled, it is raised to the top and emptied, and this process continues until the hole is entirely cleaned out.

Pumping.—The following equipment is required after a well is drilled: First, an outer casing or pipe, ranging in size from 6 to 16 in. diameter. This casing is put down while the well is being drilled. Next to this casing, a tube varying in diameter from 2 to 3 in. is placed, and this tubing forms the wall of the pump. Inside the tube is placed a series of stands of rods, screwed together, and at the lower end of the rod is attached a plunger with a ball check valve, by means of which the oil is raised in the tubing. The speed at which the well is pumped varies with the depth, the gravity of the oil, and the amount of sand present, but it usually ranges somewhere between 18 and 30 strokes of the pump-rod per minute.

Cleaning.—In some fields the wells frequently 'sand up' and the pump is no longer able to raise any oil. It then becomes necessary to pull the pump-rod and the tubing, and introduce a bailer to remove the sand. The bailer is simply a length of pipe closed at the lower end by a check valve which opens when the bailer strikes the bottom. After the clogging sand is removed, the tubing and rods are replaced, the rods are connected to the walking-beam, and the well is again ready for pumping.

Removing the Oil.—After the oil is pumped into the sump, is is necessary to pump it from thence into tanks and also to the main pump line. Until quite recently, this pumping had been done by means of a steam engine, but a rotary pump is now developed, as above described, which will take care of this part of the work in an entirely satisfactory manner. It will thus be seen that steam may be entirely eliminated from an oilfield lease, with the exception of a few fields where the oil is very heavy and filled with impurities, and where it has to be heated and some of the im-

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purities carried off before the oil is pumped into the main line.

In a great many leases there is sufficient natural gas to take care of this heating, but where this is not available, a small boiler using a few gallons of oil per day can be installed, and this part of the work taken care of without any trouble, and at exceedingly small expense. In conclusion, it is evident that the electric motor has come to stay, in the California oilfields, because it has proved itself to be in the oil industry as in all other industries, the cheapest, simplest, and best form of drive that could be devised.

Electric Power Installation at El Tigre

By JAMES W. MALCOLMSON*

THE Tigre Mining Company of Mexico, owned by the Lucky Tiger Combination Gold Mining Company of Kansas City, decided early in 1910 to enlarge its mill, which consisted of a concentrator milling three thousand tons of ore per month. The enlarged plant was designed to crush and concentrate six thousand tons of ore per month and to cyanide 7500 tons monthly. The extra tonnage cyanided was to be obtained from tailing which was stored below the old mill. Power was supplied to the old mill from four boilers, a 150-hp. Corliss engine, and two 60-hp. gas engines using producer gas made from charcoal. The total power required, including 60 hp. used for machine drills in the mine, was approximately 275. Cordwood cost $4.32 per cord, 8 by 4 by 3 ft. and charcoal $15 per ton. The fuel supply in the surrounding country was approaching exhaustion; over 150 mules and 90 men were engaged in cutting and transporting this fuel, and in the unsettled political conditions in Sonora were such that it would be practically impossible to keep an organization of this kind together. The price of fuel was steadily rising and at times it became almost impossible to get sufficient fuel to operate.

It was estimated that the enlarged plant, together with the mine, would require 750 hp. as follows:

	Hp.
Old mill, which was left unchanged	180
New concentrator	90
Cyanide plant	380
Mine and other requirements	100
Total	750

In a study of the best manner to obtain power the following alternative propositions were considered.

1. To continue using the local fuel supply and by building tramways and cheapening transportation generally, reaching a larger area of country. Power to be generated by means of wood-burning gas-producers and gas engine plant.

2. To build a steam power plant at Yzabal, the nearest railroad point, 30 miles away, and transmit electric power to the mine, using Texas or California oil as fuel at $1.70 per barrel, on the assumption that the Mexican government would remove the import duties.

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3. To build a dam on the Bavispe river, 10 miles from the mine and install a hydro-electric plant and transmission line.

4. To install a power plant at Douglas, Arizona, and transmit electric power 65 miles to the mine.

An investigation of the available timber showed that it consisted of 80% white pine and 20% scrub oak. The supply was limited, and much of the pine would be required during the next ten years for mine timbering and general construction work. It is estimated that 13,500 cords of wood, 8 ft. by 4 ft. by 3 ft. would be required, per annum, to produce 750 hp. in a well designed gas engine plant as follows:

	White dry oak.	Dry pine.	Total.
Hp-hr. per year	1,600,000	4,800,000	6,400,000
Consumption per hp-hr., lb.	3.31	3.0	.....
Total lb. per year	5,280,000	14,400,000	19,680,000
Total cords per year	2,000	10,900	13,500

Estimating these 13,500 cords at $3.25 gold per cord, equals a total of $43,875 per annum. Add coke used in the bottom of the producers, 1½% of the weight of the wood consumed, equals 150 tons per annum at $20 per ton, equals per annum $3000. Total fuel cost, $46,875.

A well designed steam plant at Yzabal with electric power transmission to El Tigre, would consume 1½ lb. of Texas fuel oil per horse-power delivered to the motors. Taking 750 hp. for 356 days equals approximately:

6,400,000 hp-hr. at 1½ lb.	9,600,000 lb.	oil
311 lb. oil per barrel equals	30,870 bbl.	oil
$1.70 per bbl. at Yzabal gives total fuel cost per annum in gold	$52,480	
Excess cost over gas fuel at the mine	$5,605	

This difference would be wiped out by an increase of $0.50 gold per cord in the cost of 13,500 cords per year. In fact, before the new power plant was in operation the price of cord wood had increased $1 per cord and the cost under any circumstances would have steadily risen. Even with wood at $3.25 per cord the estimated saving was more than offset by the greater expense for labor, repairs, and supplies with gas engines. In a plant of this size the expense of gas power would be nearly twice as much for repairs and supplies as for the corresponding items in a steam-power transmission plant. The cash expenditures per annum would be greater at El Tigre than with a steam electric plant at Yzabal even if there were no increase in the cost of wood.

Regarding first cost, it was estimated that gas engine power would be unsatisfactory unless the plant had one spare engine to allow for periodical cleaning of each engine in turn. It was estimated that a suitable plant of gas producers, gas engines, and dynamos could be installed only at El Tigre, 30 miles from the railroad for $150,000 gold, taking the European cost of engines. Engines made in the United States would cost more.

The first cost of a suitable steam plant at Yzabal with electric power transmission to El Tigre was estimated at $213,400, including economizers, as below:

The estimated cost per horse-power delivered per year using 750 hp. was $105.

Compared with power transmitted from a steam plant at Yzabal, gas engine power at El Tigre would be less

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reliable, and more troublesome, and the proposal to install a local power plant at the mine was, therefore, definitely rejected. After an expert examination of a proposed dam on the Bavispe river, this was also abandoned. The river is usually 150 ft. wide and 2 ft. deep, but at times it is 200 ft. wide and 24 ft. deep. During very dry seasons, the river is not over 6 in. deep. If a dam and power plant were built, involving enormous cost and many miles distant, a duplicate steam plant would also be necessary, and the total estimated cost proved to be out of all proportion, when compared with the other projects.

Power-plant at Yzabal erected complete	$133,000
Economizers (not considered essential)	17,000
Transmission line to El Tigre, 30 miles, 30,000 volts	30,000
Step-up and step-down transformers	14,000
Margin on a preliminary estimate, 10%	19,400
Total estimated cost	$213,400

Before finally deciding to build the plant at Yzabal, which is 45 miles south of Douglas, an investigation was made as to the possibility of securing power from that town. In Douglas, the power plant of the Copper Queen Consolidated Mining Company develops approximately 8000 hp. for the requirements of its smelter. An arrangement was made whereby the Copper Queen company agreed to install exhaust steam turbo-generators in their plant and supply electric power to the Tigre Mining company. The installation was to be paid for by the Tigre company, and the power sold on a sliding scale varying with the amount taken and the cost of fuel oil in Douglas. In August 1912 this amounted to 0.96c. per kw. hour at Douglas. The installation of an exhaust steam turbine plant at Douglas presented several advantages although the cost of the machinery, together with the 65-mile transmission line to the mine, was considerably in excess of the Yzabal project with a 30-mile transmission. The principal advantage, which led to a final decision to adopt the Douglas plan, was the cost of power.

Taking 750 hp., it was estimated that a plant at Yzabal would cost per annum $79,000 or $105 per hp. delivered at El Tigre per year. Power from Douglas delivered at the mine, it was estimated would cost slightly over $70 per hp. per year or from $54,000 to $57,000 per annum depending on whether one or two turbines were required. In other words, the Douglas project showed a saving on cost of power of $25,000 per year and it was decided in July 1910 to adopt the Douglas plan and build a line to the mine. In June 1911 power was delivered over the line to El Tigre, the revolution in Mexico causing some delay in prosecuting the work.

The plant at the works of the Copper Queen Consolidated Mining Company in Douglas consists of two 750-kw. exhaust steam turbo-generators which will work with a 50% underload or overload without any very serious loss of efficiency. The Tigre Mining company received power at the buss bars at a tension of 2200 volts. This is stepped up to 44,000 volts by means of three General Electric transformers. At the mine the current is stepped down to 440 volts and distributed to the various circuits in the plant.

The transmission is unusual on account of the small quantity of power being transmitted such a long distance. The current is 44,000 volt, 60 cycle, 3 phase, transmitted over a single line of wooden poles carrying 3 conductors of No. 4 B and S gauge, medium, hard drawn copper wire with telephone wires below. The poles are 200 ft. apart; at

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the crossing of the Bavispe river the span is 1600 feet. The cost of the line from the low tension side of its step-up transformer station at Douglas to the low tension side of its step-down transformer station at El Tigre was $161,121. Not including the transformer stations at each end, their cost was very closely equal to $2000 per mile. The line, including the transformer stations, was built by Sanderson & Porter of New York. The total cost of the exhaust steam turbo-generator plant including the steam piping, etc., was $71,894, the machinery being installed by the Copper Queen Consolidated Mining Company. During the past year, 6000 tons of ore has been concentrated monthly and 7500 tons cyanided at the Tigre mill; an average of 616 hp. is distributed at the El Tigre switchboard. The delivered cost is $86 per horse-power per year; the cost at Douglas being 0.95c. per kw. hour.

COST AND ERECTION OF POWER-PLANT AT DOUGLAS REDUCTION WORKS BUILT BY COPPER QUEEN CONSOLIDATED MINING COMPANY

Engineering:		
Engineers' salaries while engaged in drafting, blueprints for foundations, piping, condensers, etc.		$ 477.98
Foundations:		
Excavation (labor)	$ 96.19	
Anchor bolts (labor and material)	132.58	
Molds (labor and material)	468.93	
Concrete, 127½ cu. yd. (labor and material)	981.97	
		1,679.67
Hot well:		
Excavation (labor)	72.94	
Molds (labor and material)	46.86	
Concrete, 15 cu. yd. (labor and material)	238.95	
Pipe connections (labor and material)	167.14	
Steel reinforcement (labor and material)	34.81	
		560.70
Steam turbo-generator:		
(Bought from General Electric Co.)		
2 A.T.B. 4-750-1800 generators with Curtis steam turbines and accessories	28,250.00	
4 5-in. compression and vacuum gauges	11.20	
Insurance on engine	70.62	
Freight, Schenectady, New York, to Douglas	2,143.55	
Labor erecting	906.51	
Material for erecting	320.17	
		31,702.05
Switchboard:		
(Bought of Westinghouse E. & M. Co., Pittsburgh.)		
1 complete switchboard	2,455.00	
Insurance	3.89	
(Bought of Machado & Roller, New York City.)		
1 Hartman & Braun frequency meter	52.20	
(Bought of Roller Smith Co., New York.)		
2 D.C. voltmeters, range 0-150 volts; 2 D.C. ammeters, range 0-300 amperes; 2 D.C. ammeters, range 0-150 amperes	144.74	
Freight to Douglas on above parts	267.25	
Labor erecting	145.63	
Material erecting	85.54	
		3,154.25
Wiring:		
(Bought of General Electric Co., Schenectady, New York.)		
75 ft. 552-lb. 3/250,000 C.M.V.C., 3/32 by 1/16 lead, 7/64 Sec. No. 1, complete; 30 ft. 52-lb. 3/8 wire, V.C. 5/64 by 1/16 lead, Sec. No. 1, complete, 175 ft. 155-lb. 4/0 cable, R.C. 5/64 T.B.W., Sec. No. 1, complete, S. O. N. 72143; 22 lb. No. 227 compound	133.40	
Freight on the above	24.12	

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Labor erecting	117.28	
Material for erecting	18.86	
		293.66

Condensers:

(Bought of Mesta Machine Co., Pittsburgh.)		
2 72-in. type 'B' Helander patent barometric condensers	.....	
2 12 by 24 by 16-in. dry-air pumps	7,100.00	
Insurance	3.37	
Freight on the above	2,208.47	
Labor erecting:		
Machine shop, 45 hr.	$ 22.88	
Blacksmith shop, 6 hr.	3.64	
Carpenter shop, 114 hr.	55.68	
Rigging gang, 124½ hr.	332.08	
Electric gang, 384 hr.	146.83	
Special gang, 158 hr.	33.23	
Construction, 995½ hr.	400.52	
	994.86	
Material for erection	133.31	
		10,440.01

Steam and motor exciters:

(Bought of B. F. Sturtevant & Co., Hyde Park, Mass.)		
1 standard 30-kw. generator set, consisting of one 9 by 9 V.S. 7 automatic engine, complete with cylinders, lubricators, and full set of wrenches, extended sub-base for direct connection to one No. 10 C.H.P. 8 generator compound wound for 125 volts field rheostat	1,125.00	
(Bought of Westinghouse E. & M. Co., Pittsburgh.)		
1 2-brg. motor-generator set, consisting of one 30-kw. No. 8 'L' type 'S' generator coupled with 125 v. with bed plate and shaft, one No. 11 A.H. 45, 6-hp. type 'C.C.L.' motor, 2300 volts with auto starter and oil	1,000.00	
Insurance	3.87	
Freight	244.27	
Labor erecting	44.40	
Material for erecting	9.29	
		2,426.83

Water piping:

(Bought of Best Mfg. Co., Pittsburgh.)		
Cost East	3,522.87	
Freight to Douglas	1,644.09	
Labor laying and erecting	408.33	
Material for laying and erecting	110.43	
Material and labor for supports	1.23	
		5,686.95

Exhaust piping:

(Bought of Best Mfg. Co., Pittsburgh.)		
Cost East	807.94	
Freight to Douglas	336.88	
Labor erecting	83.13	
Material for erecting	33.92	
Supports and hangers (labor and material)	29.11	
		1,290.98

Steam piping and separators:

(Steam pipe bought of Best Mfg. Co., Pittsburgh.)		
Cost East	7,717.41	
(Separators bought of Griscom-Spencer Co., New York.)		
2 16-in. Stratton separators	1,089.00	
Freight on pipe and separators to Douglas	1,478.87	
Labor erecting	833.30	
Material for erection	234.59	
Supports and hangers	33.73	
(Bought of H. W. Johns-Manville Co.)		
Pipe covering, erected	2,400.00	
		13,786.90

Air piping:

(Bought of Best Mfg. Co.)		
Cost East	258.70	
Freight to Douglas	71.16	
Labor erecting	25.25	

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Material for erecting	37.05	
Supports and hangers (labor and material)	1.61	
		393.77
Total cost		$ 71,893.75

(Note.—Pipe bought of Best & Co. was shipped from Scottsdale, Verona, Pa., and Camden, N. J. Weight of pipe and separators, 340,405 pounds.)

COST OF TRANSMISSION LINE, BUILT BY SANDERSON & PORTER, ENGINEERS

Poles:		
1. First cost	$ 8,642.18	
2. U. S. freight	4,245.74	
3. Unloading, hauling, and delivery along line	3,730.57	
4. Assembling and erecting	1,348.05	
5. Digging holes and setting poles	8,610.97	
6. Customs charges and duties	121.12	
7. Mexican railroad freight (Douglas to Ysabal)	1,397.25	
		$ 28,095.88
Transmission line—Cross-arms:		
1. First cost	1,422.28	
2. U. S. freight	446.10	
3. Unloading, hauling, and delivery along line	614.30	
6. Customs charges and duties	13.78	
7. Mexican railroad freight (Douglas to Ysabal)	112.12	
		2,608.58
Transmission line—Hardware (bolts and braces):		
1. First cost	1,380.55	
2. U. S. freight	429.21	
3. Unloading, hauling, and delivery along line	1,017.90	
6. Customs charges and duties	460.90	
7. Mexican railroad freight (Douglas to Ysabal)	87.59	
		3,376.15
Transmission line—Pins:		
1. First cost	1,524.18	
2. U. S. freight	326.49	
3. Unloading, hauling, and delivery along line	167.03	
6. Customs charges and duties	184.12	
7. Mexican railroad freight (Douglas to Ysabal)	25.26	
		2,227.08
Transmission line—Insulators:		
1. First cost	7,312.99	
Inspecting and testing	308.90	
2. U. S. freight	4,046.93	
3. Unloading, hauling, and delivery along line	507.48	
4. Assembling and erecting	468.25	
6. Customs charges and duties	1,006.56	
7. Mexican railroad freight (Douglas to Ysabal)	430.11	
		14,081.22
Telephone line—Cross-arms:		
1. First cost	393.00	
2. U. S. freight	196.08	
3. Unloading, hauling, and delivery along line	43.97	
6. Customs charges and duties	167.41	
7. Mexican railroad freight (Douglas to Ysabal)	63.51	
		863.97
Telephone line—Cross-arm hardware:		
1. First cost	240.27	
2. U. S. freight	51.36	
3. Unloading, hauling, and delivery along line	16.51	
6. Customs charges and duties	51.60	
7. Mexican railroad freight (Douglas to Ysabal)	6.07	
		365.81
Telephone line—Pins:		
1. First cost	130.20	
2. U. S. freight	70.44	
6. Customs charges and duties	4.40	
7. Mexican railroad freight (Douglas to Ysabal)	7.02	
		212.06

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Telephone line—Insulators:		
1. First cost	525.75	
Inspecting and testing	18.90	
2. U. S. freight	216.59	
3. Unloading, hauling, and delivery along line	2.58	
6. Customs charges and duties	40.44	
7. Mexican railroad freight (Douglas to Ysabal)	23.57	
		827.83
Pole steps, guying and bracing (eye-bolts, guy wires, clamps, anchors, pole braces, etc.):		
1. First cost	895.53	
Labor	503.00	
2. U. S. freight	138.15	
3. Unloading, hauling, and delivery along line	168.00	
6. Customs charges and duties	176.85	
7. Mexican railroad freight (Douglas to Ysabal)	35.78	
		1,917.31
Special structures, concrete, and cribbing, incident to special construction:		
1. First cost	465.60	
Labor	973.10	
2. U. S. freight	52.22	
3. Unloading, hauling, and delivery along line	85.00	
6. Customs charges and duties	22.10	
7. Mexican railroad freight (Douglas to Ysabal)	20.63	
		1,618.65
Painting:		
1. First cost	313.43	
Labor	206.00	
6. Customs charges and duties	18.61	
7. Mexican railroad freight (Douglas to Ysabal)	0.54	
		538.58
Transmission line—Wire:		
1. First cost	18,096.29	
2. U. S. freight	2,695.78	
3. Unloading, hauling, and delivery along line	353.48	
4. Assembling and erecting	2,658.75	
6. Customs charges and duties	1,968.61	
7. Mexican railroad freight (Douglas to Ysabal)	172.90	
		25,945.81
Transmission line—Ties or clamps:		
1. First cost	279.03	
2. U. S. freight	21.38	
3. Unloading, hauling, and delivery along line	1.00	
4. Assembling and erecting	7.00	
6. Customs charges and duties	23.26	
7. Mexican railroad freight (Douglas to Ysabal)	20.40	
		5,363.05
Telephone line—Wire:		
1. First cost	3,249.41	
2. U. S. freight	388.54	
3. Unloading, hauling, and delivery along line	96.60	
4. Assembling and erecting	1,231.50	
6. Customs charges and duties	365.30	
7. Mexican railroad freight (Douglas to Ysabal)	31.70	
		1,795.92
Telephones:		
1. First cost	1,132.24	
2. U. S. freight	138.22	
3. Unloading, hauling, and delivery along line	50.00	
4. Assembling and erecting	401.63	
6. Customs charges and duties	21.82	
7. Mexican railroad freight (Douglas to Ysabal)	52.01	
		739.50
Clearing and trimming:		
Right of way, including easements or real estate and collateral costs incident thereto		1,048.96

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Pole signs		129.60
Preliminary work, including payments made by Tigre Mining Co. to J. Langston for services and expenses		4,033.75
Contractors' equipment and tool account		1,040.35
1. First cost	892.83	
2. U. S. freight	70.05	
6. Customs charges and duties	48.53	
7. Mexican railroad freight (Douglas to Ysabal)	19.94	
Labor	9.00	
Stable—operation and feed		1,373.62
Camp—equipment		817.76
Camp—expenses and repairs		271.00
Subsistence		4,061.57
General engineering and administration (New York)		76.33
General engineering and administration (local office), including surveys		5,476.84
Office	$2,436.95	
Surveys, including surveys by Tigre company	3,039.89	
Traveling expenses and board of general engineers and contractors		597.28
Transportation and expenses incident to placing any labor on job and housing of same		425.89
Medical services and expenses		24.75
Expenses due to insurrection (repairs, etc.)		1,041.57
Trail along transmission line		723.75
Station house on line 'fronteras'		62.50
Total, 'transmission line'		$112,134.99

DOUGLAS SUB-STATION

Excavation, grading, and disposition of excavated material		$257.38
Foundations of sub-station building (substructure)		142.77
Machinery foundations		191.74
Building (superstructure)		2,398.66
Brickwork	$1,400.00	
Labor and material (miscellaneous)	998.66	
Switchboard and wiring (thereof, thereto, therefrom)		1,903.05
Switchboard	$1,300.00	
Freight	49.14	
Nyelec panel and switches	47.00	
Insulators, fittings, clamps, wire, etc	365.26	
Labor	141.65	
Underground cable between switchboard and step-up sub-station		1,583.55
Cable	$1,270.01	
Cable terminals and jointing compound	28.41	
Miscellaneous material and cartage	132.99	
Labor	152.14	
Sub-station step-up transformers		8,401.64
Four 400-kva. step-up transformers	6,207.34	
Freight	1,185.30	
Drying transformers	266.00	
Miscellaneous material	21.00	
Labor	722.00	
Painting and finishing of machinery		10.02
Plumbing, lockers, and other sub-station furnishing		35.99
Contractors' equipment and tool account		153.84
Traveling expenses and board of general engineers and contractors		20.80
Transportation and expenses incident to placing any labor on job, and housing of same		93.50
Tests of equipment		948.49
Steam and electric power	745.00	
Miscellaneous material	203.49	
Total Douglas sub-station		$ 16,141.43

EL TIGRE SUB-STATION

Sub-station proper		5,294.55
Switchboard and wiring (thereof, thereto, therefrom)		5,362.26
Switchboard	3,780.00	
Freight, customs charges, and duties	769.47	
Nyelec panel and switches	106.00	

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Insulators, fittings, clamps, wire, etc.	594.94	
Labor	111.85	
Sub-station step-down transformers		8,899.26
Four 320-kva. step-down transformers	4,989.09	
Freight, customs charges, and duties	1,964.24	
Miscellaneous material	531.98	
Labor	1,413.95	
Traveling expenses and board of general engineers and contractors		32.70
Transportation and expenses incident to placing any labor on job, and housing of same		70.00
Tests of equipment		173.58
Total El Tigre sub-station		$ 19,832.35

RECAPITULATION

Transmission line	$112,134.99
Douglas sub-station	16,141.43
El Tigre sub-station	19,832.35
Total	$148,108.77
Fees paid Sanderson & Porter	13,000.00
	$161,108.77

(The total shown above, amounting to $161,108.77, includes disbursements made by Sanderson & Porter amounting to $132,743.48, and as reported by the Tigre Mining Co. amounting to $28,365.29.)

Cascade Scenic Highway

By A. P. DENTON*

THE Cascade scenic highway, as proposed, will follow roughly, the main line of the Great Northern railway. Having Seattle for its western terminus; it will pass through the following cities and towns: Everett, Monroe, Sultan, Index, Skykomish, Scenic Hot Springs, Stevens Pass, which is the summit of the Cascade mountains, Cascade, Berne, Leavenworth, Cashmere, and Wenatchee, situated in the famous Wenatchee valley on the Columbia river. The total distance between termini is about 175 miles, of which 129 miles lies along existing traveled roads. Of the uncompleted portion, 6 miles is in Snohomish county between Index and Baring, 28½ miles in King county between Baring and the summit of the Cascade mountains at Stevens pass, and 12 miles in Chelan county between the last mentioned point and the town of Berne.

The King county section of the Cascade scenic highway will begin at the line between King and Snohomish counties, at an elevation of about 750 ft. and should parallel the Great Northern railway for the first six miles. At this point there is in use a 300-ft. suspension bridge with a 6-ft. roadway. This bridge has been in use several years and would have to be replaced by a new structure having a roadway at least 10 ft. in the clear. From here the road will cross to the south side of the railroad and approximately parallel it to the town of Skykomish, a distance of about 3½ miles, the elevation being 930 feet. A 100-ft. span will be re-

*Chief Deputy County Engineer, Seattle, Washington.

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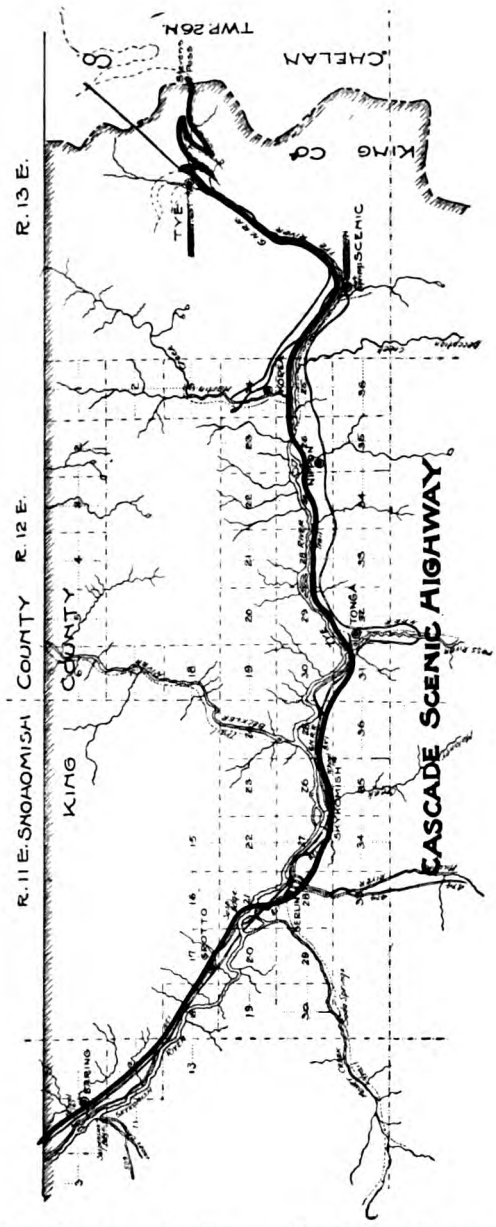
quired to bridge Miller river which is a small stream during the summer months, but a raging torrent in winter. This river has been known to rise 10 ft. in twenty-four hours. A pile trestle about 600 ft. long will also be required to cross a swamp near Skykomish. From Skykomish east, the highway will parallel the railroad for about three miles, crossing it overhead at this point. About one-half mile farther on, it will cross the Foss river with a 100-ft. span.



Thus far, the route has been through logged-off lands affording frequent glimpses of the Skykomish river and of the heavily timbered mountains which rise to an elevation of 5000 ft. on either

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side. After crossing the Foss river the route will lie along the Tye river, a beautiful mountain stream, and will traverse virgin forests of hemlock, cedar, and Douglas fir until Scenic Hot Springs is reached, a distance of about eight miles. In this distance, two bridges will be necessary, an 80-ft. span over the Tye river and a 60-ft. span over Martin creek. From the beginning of the King county section to Scenic Hot Springs, a line can be located having a 5% maximum grade, which will require no heavy construction and very little, if any, rock work. For the greater part of this distance, the grade should not exceed 3%. From Scenic Hot Springs, the elevation of which is 2106 ft., to Tye is a distance of three and one-half miles and the difference of elevation is 1000 ft. If a uniform grade is supported between these two points, a 5.5% grade can be located which, however, will necessitate very heavy construction. It is my opinion that a 10% maximum grade should be used for this section of the road. This will give more latitude in location and will result in much lighter construction. One bridge will be required on this section, a 60-ft. span over the Tye river.

At Tye, the highway will connect with the Great Northern switchback, which was abandoned upon the completion of the Cascade tunnel about twelve years ago, and will follow this old grade to the summit of Stevens pass with a grade not to exceed 3.5%. This grade, although abandoned twelve years ago, is in remarkably good condition. The old bridges and culverts are either burned or rotted out. Some of these should be replaced and some of the longer bridges should be eliminated by changes of alignment. Such changes of alignment, while they will increase the curvature materially, will be entirely practicable for wagon or motor traffic. In order to make the old grade passable, the ties, logs, and boulders must be removed and a road grader run over it. Practically the whole four miles of this switchback runs through a decomposed granite formation, which will make a splendid roadbed. For a mountain road, the cost of construction of this highway will be comparatively small, and with the exception of about six and one-half or seven miles, the maintenance will not be great. From a point about three miles below Scenic Hot Springs to Tye the maintenance cost will be heavy owing to the frequency of slides and avalanches during the winter months. For a considerable part of this distance, the railroad, which is above the proposed highway, requires the protection of snow sheds. The largest one of these is a reinforced concrete shed one-half mile long situated immediately west of the town of Tye.

The average snow fall on the lower half of the King county section is reported to be from two to three feet and on the upper section from three to five feet. Under such conditions this highway can be kept open to travel from seven to eight months of the year. There is at present before the voters of King county, a $3,000,000 bond issue for the construction of a system of highways throughout the county, which if approved by the people—and at present, the general opinion is that it will be— will carry with it an appropriation of $165,000 for the construction of this road. With the approval by the people of the bond issue, the completed trans-mountain highway will be assured, thus encouraging tourist traffic and giving a practicable outlet to about 1100 residents of this country.

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Large Volume Metering of Natural Gas

By CHESTER EARL WOOD*

METHODS and appliances employed in the metering of natural gas in large quantities are of special interest to the engineering profession at the present time in view of the great development now under way in that branch of the oil industry. It rarely comes within the scope of the average engineer's practice to come into intimate association with natural gas measuring stations, unless of course he be a gas or petroleum engineer. A knowledge of this subject must be acquired in the fields, as very little attention is given to it in technical books or schools, its somewhat limited quantity and isolated sources of supply contributing to make a knowledge of the methods of its production and direction to the use of man a specialized branch of the engineering profession. This phase of engineering practice is interesting from the standpoint of mechanical operations and mathematical principles, inasmuch as it again confirms the impossibility of conducting any large commercial enterprise without an understanding of its basic engineering principles.

Inasmuch as the chief source of natural gas in California lies in the western border of the Midway oilfields, in the Buena Vista hills, in Kern county, I shall confine myself to the methods employed in this district for the measuring of intake and output at the distributing station from which the gas is either 'jobbed' or sold direct to the consuming company. It might be well to state that in practically all cases the delivering or wholesaling company builds and completely equips the measuring station with all necessary fittings, regulators, manifolds, meters, etc., and that the receiving company, whether it be a jobber or retailer, uses the same meter charts to determine the volume of gas it must pay for, as the delivering or wholesaling company uses for determining the volume delivered—the meters being tested perhaps twice a year by either the manufacturer's representative in the presence of the officials of both the delivering and consuming end, or by the engineers for both parties involved. There are various devices in the market for determining whether a meter is fast or slow. It will not be necessary to go into details here but the formula for determining by what percentage a meter is fast is:

$$\frac{\text{Meter reading—prover reading}}{\text{Prover reading}} \times 100;$$

and that for the percentage slow:

$$\frac{\text{Prover reading—meter reading}}{\text{Prover reading}} \times 100$$

For example: Say a slow meter registering 10 showed 12.5 cubic feet on the prover, then

$$\frac{(12.5 - 10)}{12.5} \times 100 = 20\% \text{ error slow.}$$

There are several types of meters on the market but generally only two different standard types are used in this district.

*Consulting Engineer, California Natural Gas Building, Taft, California.

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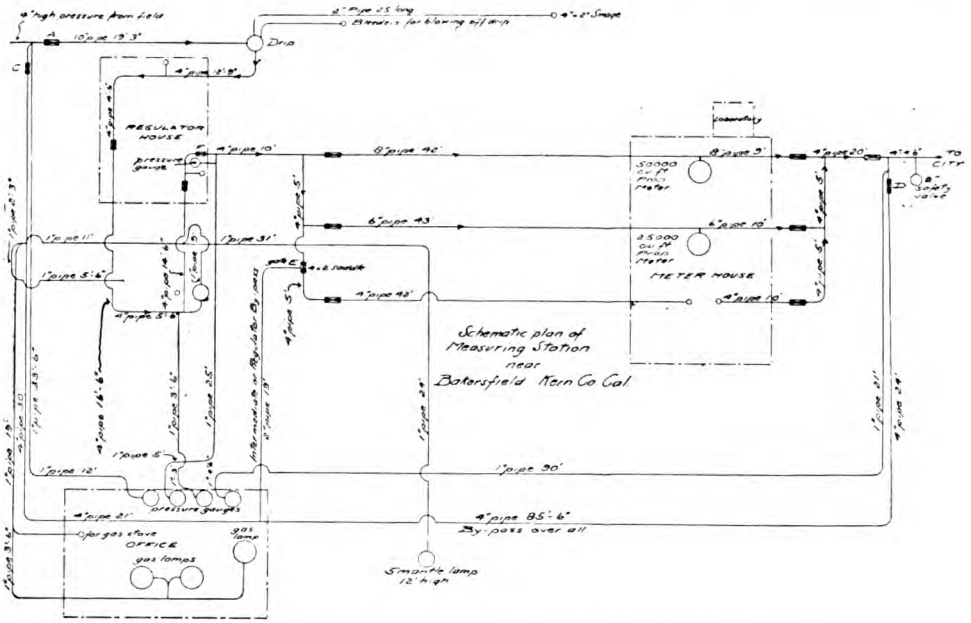
The proportional gas meter, varying in capacity from 3000 to 100,000 cubic feet of gas per hour, is the class of meter which is herein discussed. In order that the excessive strain that would ultimately ruin the recording apparatus in the meter, and reinforcements that would necessitate an unwieldy piece of mechanism be done away with, only a very small percentage of the gas passing through the meter enters the recording



SCHEMATIC PLAN OF MEASURING STATION, NEAR BAKERSFIELD, CALIFORNIA.

mechanism. In meters designed for low pressure, regulators reducing the well or line pressure to that for which the meter is designed are placed ahead of the meter. Then again, high-pressure meters have no regulator manifold; these are used where the pressure must be high after passing through the meter to force the gas to its destination. From a proportionate amount of the gas that is registered, the total amount is recorded on the dial and chart by a system of gears which is designed according to the 'proportion' factor of the meter. For instance, if the meter is designed so that only 1/20 part of the gas passes through the registering apparatus, the ratio of the gearing of the registering apparatus to that of the recording dial hand will be as 20 is to 1. Various types of meters have their individual method of accomplishing this result, and may be closely studied from manufacturers' catalogues.

The clock and chart resemble any ordinary gauging apparatus. The chart makes a complete revolution every 24 hours, the pressure lever tracing the variation in pressure during that time, and the volume lever the number of cubic feet passed. The latter hand works on an eccentric lever from the 1000 ft. dial hand, the quantity of gas in thousands of cubic feet during the 24 hours may be obtained by counting the oscillations of the wave traced on the chart from crest to crest, and by applying the multiplier or density factor for every change in pressure

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noted. In measuring gas it is always desirable to determine the pressure of each 1000 cubic feet passing through the meter in order that the operator may obtain the exact quantity passing through the meter. This should be accomplished by the use of a recording volume and pressure gauge with the time chart. These gauges are made for pressure varying from 50 to 500 pounds.

Natural gas is sold to the retailing company in this district by the cubic foot at a standard pressure of 4 oz. per sq. in. or 36 lb. per sq. ft., at a temperature of 60° F. and mean atmospheric pressure of 14.4 lb. per sq. in. (29.34 inches mercury) which are normal conditions. Therefore in order to arrive at the correct number of feet when the gas is measured at a pressure greater than 4 oz. the following formula, derived directly from Boyle's law, is used. The correction for change in temperature is generally omitted:

$$Q = q \frac{(p + h)}{h + 0.25}$$

In which Q = cu. ft. required
q = cu. ft. shown by the meter
p = gauge pressure in pounds
0.25 = 4 oz. reduced to pounds

By substituting the known values in the above it becomes:

$$Q = q \frac{(p + 14.4)}{14.65}$$

For example: Suppose the meter reading or q shows 2000 cu. ft. and the pressure p. shows 30 lb. per sq. in.: required to find the quantity of gas at a pressure of 4 oz., then,

$Q = 2000 \frac{(30 + 14.4)}{14.65} = 6061.4$ cubic feet at standard pressure of 4 oz. per square inch.

If the gas is measured at atmospheric pressure then,

$$Q = q \frac{(p + h)}{h}$$

To determine Q for any base, as 8 or 10 oz., 1 or 2 lb., as is sometimes used, merely substitute a base in terms of pounds in the formula.

The multiplier, or density factor, is directly determined from the formula:

$$\frac{(p + h)}{(h + b)}$$

where b is the base at which the gas is sold. For normal conditions, the atmospheric pressure being 14.4 lb. and say the desired base is 8 oz., then a vessel containing 100 cu. ft. of gas at a visible pressure of 0.5 lb. (8 oz. = 0.5 lb.) and a total pressure = 14.4 lb. unmeasured + 0.5 lb. measured = 14.9 lb. be filled so that the visible pressure became 15.4 pounds, the quantity would be doubled and equal to 2000 cubic feet. Therefore 0.5 lb. is seen on the gauge, to which there was added 14.9 lb., making 15.4 pounds.

$$\frac{15.4 + 14.4}{14.9} = 2,$$

the multiplier at a gauge pressure of 15.4 lb. from 8 oz. base.

An approximate method for determining the multiplier is as follows:

Multiply the number of pounds shown on the gauge by 0.068 and add 1. Suppose the gauge shows a pressure of 30 lb., then $30 \times 0.068 + 1 = 3.04$. This method will give a result about 1/3 of 1% greater than by the former method, but for practical purposes this simple formula will answer. Extensive tables have been compiled showing the multipliers or densities of the gas at pressures from 0 to 200 lb., and which can be obtained from any proportional meter manufacturer on request.

To determine the quantity of gas output at the wells into an entire system so that a check may be obtained on the production and consumption, the Pitot tube is usually employed. This is an instrument for determining the velocity of flowing gas by means of its momentum. Size of pipe known, the

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velocity of the gas being determined, the volume may easily be calculated. The principles of the Pitot tube have been thoroughly expounded by able authorities and therefore need no explanation here.

The sketch given shows the scheme of the arrangement of regulators, by-passes, meter manifolds, etc. of a well known measuring station at Bakersfield. The gas entering at the point shown on the sketch, passes through the station as indicated by the arrows and out to the city's gas system. The regulators are installed to reduce the pressure to 50 to 80 lb. before passing through the proportional meters. The manifold is designed so that either meter may be used, in case one needs cleaning or repairing, or so that both may be used simultaneously. In the event of the regulators and meters becoming out of order, or plugged, the gas may be made to by-pass the station, through the 4-in. by-pass over all in order to insure a continuous supply to the city. By closing gates a and b and opening gates c and d the gas takes the course of the by-pass, thus making it possible to make any necessary repairs. However, should the regulator only become impaired the gates a, f, and d are closed and c and e are opened. In this manner the gas may be metered while repairs to the regulators are affected. The drip is shown on the sketch in the horizontal plane, but the vertical view would appear very different. It is merely a receiver made of 10-in. pipe, and fittings extending 9 ft. below the ground surface and 6 ft. above where the outlet for the dry gas is taken off. At the end extending below the ground, are two 2-in. taps, with gates and 'bleeders,' made into a drip-pot, and are so arranged that the distillate and water contained in the gas, and which is separated to a large extent by the drip, may be blown off through the 'bleeders.' If the gas is not clean, free from moisture and dirt, the meters would have to be dismantled and cleaned very often.

The practice in metering large volumes of natural gas as given above, while it will not meet the conditions in all districts, in the main adheres as closely as possible to the general practice.

An Example of Internal-Combustion Engine Operation

EUROPEAN practice has thus far been the basis of practically all published matter concerning the operation of the internal-combustion crude-oil engine. The Diesel type of engine has, however, begun to obtain a foothold in the United States, and there is no doubt that it will soon find a wide application in the solution of power problems wherever crude oil is available, especially in the territory accessible to the Texas and California oilfields. It is especially acceptable for use in localities where fuel forms a large portion of the total power cost, and the high thermal efficiency and consequent low consumption of fuel is of prime importance to the power user. An interesting example of the economies that may be achieved through the use of the Diesel type engine in isolated power plants is shown in an article ap-

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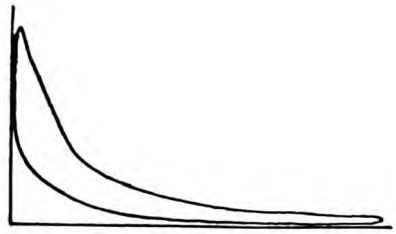
pearing in the *Mining and Scientific Press* of December 14, 1912 by W. S. Noyes. The Presidio Mining Co. operating a pan-amalgamation silver mill at Shafter, Texas, had been driving its mill with a 16 by 36-in. Reynolds Corliss engine of 115 b.hp. which was coupled



TYPICAL INDICATOR CARD, DE LA VERGNE INTERNAL-COMBUSTION ENGINE.

direct to the main mill countershaft from which the power was transmitted to the various mill accessories by belt. Texas crude oil, specific gravity 0.927, weight 324.66 lb. per barrel of 42 gallons, was used as fuel for generating steam, the quantity required being 2.882 lb. per brake horse-power hour, which in view of the fact that the engine was simple and non-condensing, is not high. This engine was replaced by a 20 by 34½ in. Diesel type, 130 brake horse-power engine manufactured by the De La Vergne Machine Co. This engine has been in operation for a sufficient length of time to make a comparison between the two types of prime mover not only interesting, but conclusive as far as such conditions as exist at the plant of the Presidio Mining Co. are concerned. The builders of the engine guaranteed that the fuel consumption at full load would not exceed 0.6 lb. of crude oil as described above per brake horse-power hour, so the purchasers were assured of a reduction of nearly 80% in fuel consumption, provided the engine did no more than meet the guarantee.

Mr. Noyes has given the following statement of fuel consumption comparing the two types of prime mover, this statement covering average operating conditions in each case and not tests after a careful grooming by skilled operators.

COMPARISON OF FUEL CONSUMPTION

Engine.	Pounds oil per b.hp.-hr.
De La Vergne	0.425
Corliss	2.882

It will be noted that the ratio between the two is 1:6.8 and that the De La Vergne engine in actual practice exceeded the guarantee of fuel consumption by 29%. The indicator card shown is typical of average operating conditions, and gives the following results:

Mean effective pressure per square inch, pounds	69
Indicated horse-power	154
Mechanical efficiency, per cent	85
Brake horse-power	130.9
Specific gravity of oil	0.924
Oil consumed per brake horse-power hour	0.375
Revolutions per minute	164
Initial pressure, pounds	447

As the pan-amalgamation process involves the use of steam in double bottoms in the pans, the exhaust steam from the Corliss engine was formerly available for this purpose. After the De La Vergne engine was installed, this source of supply was no longer available. A boiler was therefore used for supplying low-pressure steam to the pans, making the comparative total fuel consumption for the works as follows:

	Pounds oil per b.hp.-hr.
De La Vergne engine	0.425
Steam for heating pans, referred to terms of horse-power	0.325
Total	0.750
Corliss engine	2.882

Ratio, 1: 3.85.

At this rate the average daily saving in fuel cost based upon operating 24

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hours per day under full load conditions is $44.

Mr. Noyes states that the De La Vergne engine is of substantial and heavy design, the material and workmanship being of the highest type. Contrary to the general opinion that engines of this type employing such high compression pressures required frequent shut-downs for repairs, this engine is in operation from 98 to 99% of the time, such delays in operation as have occurred have been due to necessary adjustment of the oil-feeding mechanism. The spray valve is easily clogged by the carbonization of oil or by any sediment in the oil if it is not carefully strained. The delays at Shafter were due to the clogging of the spray valve and some minor defects in the air-compressor and its valves. All of these defects are difficult of detection except by experienced men, and such men are scarce, particularly in frontier districts. When the use of this type of engine becomes general, however, this difficulty will disappear, and there is no doubt that the field for this type of engine is a large one and that a due appreciation of its exceptional economy of operation is becoming more and more apparent to power users. American manufacturers are prepared to meet the expected demand.

THE Engineers' Club of San Francisco organized in the summer of 1912 has done much, through a series of weekly informal luncheons, to promote social intercourse among engineers in the West. Plans are now under consideration toward acquiring permanent quarters that will furnish adequate facilities for the entertainment of members and their guests.

PALM COURT IN THE PALACE HOTEL, WHERE THE MEMBERS OF THE ENGINEERS' CLUB OF SAN FRANCISCO GATHER WEEKLY.

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The Engineering Digest

Proposed Knight's Landing Cut

[Flood control in the Sacramento valley is a matter vitally effecting the interests of thousands of people. The annual recurrence of disasters due to floods is no longer regarded as an act of Providence and beyond the power of man to guard against. The institution of the by-pass method of flood control involving an expenditure of $33,000,000 has been recommended by the engineers of the California Debris Commission as a subject for action by the Federal Government. The time that must elapse before action may be expected is so great, however, that steps to prevent, as far as possible, the great losses that come with every flood season must be taken by private enterprise. The City of Sacramento will expend $887,000 for the construction of a by-pass above the city for its own protection, and now an association known as the Knights Landing Ridge Committee, including a number of owners of large holdings of land in the vicinity of Knight's Landing is about to undertake similar work. Haviland & Tibbetts of San Francisco, have made an exhaustive examination of the project and the following is a brief abstract of the salient features of their report.—EDITOR.]

UNDER conditions which have now developed, the proper control of the flood waters of Colusa basin, the protection of the Knight's Landing ridge, and the town of Knight's Landing, and the reclamation of the valuable lands in the upper end of Yolo basin, require the immediate cutting of the Knight's Landing ridge and the closing of the river levees at the mouth of Sycamore slough. The river levee must be closed, because in the majority of years the water rises higher than the Knight's Landing ridge, and the high water plane is rising from year to year and until the river is substantially leveed, it is a constant menace to the town of Knight's Landing and to the farms and improvements on the Knight's Landing ridge and the land below, including that in District No. 730, which is now inadequately protected from waters overflowing the ridge. The canal must be constructed in such a way that it will insure the Knight's Landing ridge from being overtopped, with the consequent destruction of property below.

The canal must be so designed that it will insure the safety of the levees now being completed by Reclamation District No. 108, and thus render possible the immediate reclamation and profitable use of all this land. The work must be accomplished in such a way that the unreclaimed land west of the proposed levees of Districts No. 108 and 787, will never be flooded to any greater extent than heretofore, and will be completely and rapidly drained as soon as the level of the waters at the outlet in Yolo basin will permit. This should be accomplished in such a way as to generally permit farming of this land. The canal should be extended and completed in such a way that no damage could accrue to the lands lying on the south slope of, and below the Knight's Landing ridge. This requirement means that the levees should be carried well above high water marks, and above the flow line in the canal, down to such points as will always be flooded at times of high water in Yolo basin. Under present conditions this would mean only as far as the south leveee of District No. 730, as the land below is annually flooded from Cache creek, and from back water in Yolo basin. The canal, however, should be constructed in such a way as to not increase the difficulty of the reclamation of this land, and this means that it should be carried as far as the edge of the main Yolo basin by-pass of the Debris Commission, as finally fixed by the Reclamation Board, and it will be herein assumed that

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this will coincide with the preliminary location as shown in the published report. If no waters are allowed to escape from the canal above this point, then no injury can be done to the lands above, as the slope is toward the south, and in times of high water the land below District No. 730 is submerged. No damage can be done by discharging waters at the line of the by-pass as under the present law it would be impossible to reclaim land below, and when the Debris Commission plan is finally consummated, the proposed cut will be a portion of the completed work.

In the statement of the problem given above, the guiding principle has been the unity of the interests involved, and the formulation of a plan of general benefit to the entire community, and to the entire region affected. Particular care has been taken to so design the cut that no possible damage can be done to any interests and so that the completion of the work will leave all interests in better condition than they are at present. The proposed work will permanently prevent the overtopping of the ridge and the constant menace to the town of Knight's Landing from the river, in season in which the water rises to the level of the crest of the ridge, and the river is as high or higher. The proposed work will, in general, render possible the final reclamation, including drainage and protection from flood waters, and the consequent settlement, improvement, and intensive cultivation of a vast area of land, the most fertile in the state, which at present has its usefulness greatly and unnecessarily impaired by the constant and growing uncertainty and danger from flood waters.

The cut will be designed for a capacity of 18,750 sec. ft. with the water surface at elevation 38.3 ft. at Knight's Landing, and 20,000 sec. ft. with the water surface at elevation 39 at Knight's Landing, and the design will be such as to permit of ultimate enlargement to a capacity of 30,000 sec. ft. with the water surface at elevation 44 at Knight's Landing. Two alternate alignments are suggested, starting close together at the upper end, and ending at the same point, with the lower 8150 ft. coinciding. One of these alignments, called the eastern alignment, is the shorter and more direct route and occupies lower ground, thereby involving less excavation than the other route, but has the disadvantage of going directly through the centre of Reclamation District No. 730. The other alignment, called the western alignment, is 2500 ft. longer, but goes around District No. 730.

The eastern alignment starts at the south levee of the Fair ranch (Reclamation District No. 787) at a point about one-half mile from the bank of the Sacramento river, just north of Knight's Landing. It crosses the main county road from Knight's Landing to Woodland, at a point near the crest of the Knight's Landing ridge, about 1600 ft. from the Fair ranch levee. About one-half mile below its upper end, it crosses the S. P. R. R. embankment and enters Reclamation District No. 730, then continues on a tangent to Roseberry slough 1¾ miles farther down, then follows in a general way the course of Roseberry slough, with easy curves, none of which are sharper than 3° (rad. 1910 ft.), to the south line of District No. 730. The remaining 2¾ miles of its length are on unreclaimed and unimproved land in Yolo basin. The right of way passes tangent to the south corner of a small back levee on the Hershey estate, it then passes tangent to the line of the Cache creek inlet of the California Debris Commission, and ends at the north line of the main Yolo basin by-pass, at a point immediately north of the mouth of the Cache creek inlet. The total length up to the Fair levees is 35,600 ft., or about 6¾ miles. About 14,300 ft., or about 40% of this, is on unimproved property.

The western alignment starts at a point about 1000 ft. farther west than the eastern alignment, or about ¾ mile from the river. It crosses the main county road about 900 ft. from the Fair ranch levees, crosses the old channel of Cache creek slough near the crest of the Knight's Landing ridge, 2200 ft. from the Fair ranch levees, crosses a second road at the S. P. R. R. embankment at a point 6100 ft. from the upper end of the cut, then parallels the S. P. R. R. for about 4200 ft., then makes a sharp turn with a 10° curve (rad. 574 ft.) near the western corner of Reclamation District No. 730, then parallels the southwest line of District No. 730, cutting off two corners and crossing the south line of the district at a point 19,300 ft. from the upper end and 18,900 ft. from the lower end of the cut. It then runs on a tangent to join the eastern alignment at the south corner of the Hershey levees. The total length is 38,200 ft. or about 7¼ miles. About 18,900 ft., or about 50% of the total length is on unimproved land south of the

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levees of District No. 730. Another 4500 ft. is on unimproved but somewhat higher land, southwest of the levees of District No. 730.

The available fall through the canal depends upon the estimated water-level at its outlet in Yolo basin. At present this has probably seldom, if ever, exceeded elevation 33, except when the river levee failed in the immediate vicinity. In the design of the cut, however, the only elevation considered will be the maximum which the water could reach with the by-pass project of the California Debris Commission completed, or elevation 34.5. With the water-level at Knight's Landing at elevation 38.3 this would give an available fall of 3.8 ft. The canal will actually be designed to have a capacity of 20,000 sec. ft. with the water at elevation 39 at Knight's Landing and 35 at the lower end, giving an available fall of 4 ft. in the total length of 35,600 ft. on the eastern alignment and 38,200 ft. on the western alignment. This is equivalent to a slope of 0.59 ft. and 0.55 ft. per mile on the eastern and western alignments respectively. An additional rise of about 0.25 ft. in the operating level at Knight's Landing would give the same slope of 0.59 ft. per mile to the western alignment that the eastern alignment has. It is assumed that if the western alignment is adopted this rise will result and no further attention will be paid to the different lengths of the two alignments as it effects their capacities. When, by reason of additional reclamations in Colusa basin it becomes necessary to increase the capacity of the cut, this can be readily accomplished by raising the water-level at the upper end, and thus increasing the slope or grade, as the estimated high-water mark at the lower end is fixed.

On the eastern alignment the ground elevations at the crest of the Knight's Landing ridge near the beginning of the cut, are about 40, decreasing to 31 ft. at the S. P. R. R. track. Inside Reclamation District No. 730, the elevation is about 30 ft. at the upper end, 26 ft. near the centre, and 28 ft. at the lower end. South of the district the ground gradually drops from elevation 28 or 29 near Grays bend to elevation 22 at the lower end along the western line of the Yolo by-pass. On the western alignment the elevation at the crest of the ridge is nearly 41 ft., dropping to 32 ft. on the section paralleling the railroad track, then after crossing the railroad track dropping on a gradually descending grade to elevation 28, near the point of juncture with the eastern alignment, and finally to elevation 22, at the lower end. It will be seen that the length of relatively high ground is much greater on the western alignment than on the eastern alignment. The nominal grade line for the bottom of the canal is fixed at elevation 24 at the upper end, and 22 at the lower end, the latter figure being somewhat above the ground-level at the lower end. This gives a nominal water depth at the upper end of 15 ft. and at the lower end of 13 ft. In order to facilitate the complete drainage of the lowest lands west of District No. 108's levees, in lower Colusa basin, portions of the canal formed by dredge borrow pits, and aggregating 120 ft. in width, will be excavated throughout the entire length down to at least elevation 22, which is about 4 ft. lower than the lowest lands outside of District No. 108's levees.

The dredge cut along the south line of the Fair ranch at the upper end of the canal should be closed, permitting of the closing of the river levees at the mouth of Sycamore slough immediately above Knight's Landing. The lowest land outside of District 108's levees is about elevation 26, or 4½ ft. higher than the land in Yolo basin, at the lower end of the proposed cut. The reclamation of this low lying land is possible only by building high levees and raising the operating level in the proposed cut. It has been suggested that gates might prove useful in the cut to prevent back water in Yolo basin flooding the low lying lands of Colusa basin. It is hardly within the range of possibility that the water will stand 5 ft. deep in the upper end of Yolo basin except when there is also flood water flowing through Colusa basin. As soon as the flood water subsides in Yolo basin, the proposed cut will effect the immediate drainage of all of the rest of Colusa basin, outside of District No. 108's levees. When this remaining land is reclaimed, it must be by the construction of levees paralleling those of District No. 108. In this case the only land which could be flooded by water backing through the cut would be that inside of the canal formed by the parallel lines of levees between Jacobs point and Hannum bridge. When the project of the Debris Commission is completed, water will be diverted into Yolo basin from the Fremont weir only at relatively high stages, and for short periods,

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so that except during floods the only waters which could back through the canal would be from Cache creek. Cache creek, however, drains the mountain area immediately adjacent to the Colusa basin watershed, so that general storms which cause floods in one of these drainage areas affects the other similarly. There is little probability that Cache creek, after spreading out into a very wide area of the by-pass, would ever raise the water as much as 4½ ft. in the by-pass, except at such times as there are also large amounts of runoff from the Colusa basin drainage area.

Having assumed the maximum height at which the water will stand, and also the elevation of the bottom of the cut, and the quantity of water, preliminary cross sections were computed having various depths of cut or what is the same thing, of various depths of water on the berm. The coefficient 'n' in Kutter's formula was taken as 0.03 and the slope 's' at 0.0001117, which corresponds to a fall of 0.59 ft. per mile. Preliminary cross sections were computed both for single channels and for two separate channels. With a slope of 0.59 ft. per mile, the cross sectional area required to carry 20,000 sec. ft. is between 6000 and 6500 sq. ft. at different depths of cut. The bottom widths range from 372 to 400 ft., depending upon the change in the wetted perimeter and consequently the hydraulic radius, for the different sections. The velocity ranges from 3.10 to 3.30 ft. per sec. Preliminary sections were also determined for two channels. In the case of all cut, it is found that two channels each 196 ft. on the bottom are required. On account of the cost of right of way, it was decided to abandon the construction of two channels. Since the theoretical cross sectional area required for 20,000 sec. ft. ranges from 6000 to 6500 sq. ft., it was decided to adopt 6250 sq. ft. as the minimum effective area in all cases. With an effective cross sectional area of 6250 sq. ft., mean velocity of flow becomes 3.20 ft. per sec. in order to discharge 20,000 second feet.

For all except the extreme upper end, the bulk of the maximum carrying capacity of the canal is above the natural ground surface, and hence the water is carried against levees constructed from material borrowed in the canal excavation. It is assumed that all of the excavation will be done under water, hence the levees will be built of wet material. In all cases, a 20-ft. berm has been left between the edge of the cut and the inner toe of the levees. The side slopes of all levees have been made 1 on 3. When the material required for the excavation is not sufficient to build levees at least 6 ft. above the highest water surface, then the levees are given a crown width of 10 ft., 4 ft. above the high water marks. It is assumed that all excavations will be made by clamshell dredges. As the largest dredges require from 7 to 8 ft. of water to work in, and it is desirable to be able to prosecute construction work without injuring the adjacent land, provision is made for the construction of dredge cuts on either side of the channel to a depth of at least 10 ft. and a bottom width of at least 60 ft., thus allowing the largest dredges to work with the water surface not closer than 2 ft. from the ground. All side slopes in the cut are assumed at 1 on 1. On the assumption of a uniform slope of 0.59 ft. per mile for the water surface, and an effective cross sectional area of 6250 sq. ft., 7 typical cross sections were computed for depths of water over the berm or ground surface differing by 2 ft. In all cases where the depth of water on the berm is 9 ft. or less, the excavated material is sufficient to build up a spoil bank which is 6 ft. or more above the water surface at flood stages. For such sections the outer toe of the levees is set inside of the line of right of way in order that if desired in the future the levees may be raised as required and thus reach to the edge of the rights of way. The position of the toe is determined upon the assumption that the operating level of the water surface may be 5 ft. higher at some time in the future, and, therefore, the levees will have to be raised, until their crowns, with a 10-ft. width, are at least 4 ft. above the future high water surface. If large dredges are available it may prove desirable to set even their lower levees back to the edges of the right of way in order that future enlargements may be under better control.

The nominal grade of the cut has a uniform slope from elevation 24 at the upper end, to 22 at the lower end. The actual lowest portions of the cut are determined, however, by the requirement for keeping the large dredges afloat, and are 10 ft. below the natural ground surface. Any portion of the cut, however, below the nominal grade line is not considered in computing

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the capacity of the cut, partly because of the danger of silting up when the flow through the canal is small because of the fact that any material below elevation 22 is lower than the ground at the outlet of the canal. In certain sections, however, the portions of the excess area of the dredge cut above the nominal grade line are utilized as effective carrying area, by balancing them with equal areas above grade in the centre of the cut. The real requirement is that 6250 sq. ft. of area be provided at any cross section above the nominal grade line and below the estimated high water surface. At the extreme lower end of the cut there is a large amount of cross sectional area below grade required for making the dredge cuts, or for building up the levees. This occurs, however, only for a short section. The total volume of excavation, measured in the cut, is estimated to be for the eastern alignment 3,135,200 cu. yd. and for the western alignment 4,556,300 cu. yd., a difference in favor of the eastern alignment of 1,421,100 cu. yd., or 45 per cent.

The cross-sections have been carefully designed so that it will be possible to construct the entire canal with floating clam-shell dredges. The bulk of the work, except for a limited distance through the ridge, can be done with dredges of ordinary size, say, with 150-ft. booms, and a considerable portion of it with even smaller machines. The completion of work, however, will require two of the largest dredges with a length of boom of 185 ft. or more. The maximum section shown has a width of 682 ft. between the tops of the levees, requiring material to be placed 341 ft. from the point at which it is obtained. It should be noted, however, that there is only a very little of the work through the crest of the ridge, which has such a severe requirement. All but about one-half mile of the eastern alignment, and one mile of the western alignment, can be readily finished with dredges having 175-ft. booms. If is proves impractical to obtain dredges with booms over 175 ft. long, then it will still be possible to complete the work by handling a small part of the material twice. The cross-sections provide for borrow pits with a 60-ft. bottom width, dug 10 ft. below the ground surface at all points, one on either side of the cut. The largest size dredges require 7 to 8 ft. of water to work in. It would thus be possible to complete the work with the largest size machines, and without raising the water closer than 2 to 3 ft. from the ground surface. This would permit of working in any season of the year, without injury to the adjacent land.

Four dredges should be used in the work. Two of them should have a length of boom of 175 to 185 ft. The other two need not have more than 150 ft. If desired, four dredges of this smaller size could be used. The dredges should preferably begin at the upper end and work southward. They can be brought in from the river through lower Sycamore slough and the Fair ranch borrow pits, to the upper end of the work, and the estimates will provide for bringing the machines in in this manner, including the moving of the highway bridge. In order to prevent the wet material in the levees from running out into the fields to an objectionable extent, the levees should be built up in layers with side slopes, as flat as 1 to 3. It ought not to be necessary to allow the material to settle more than 30 to 60 days, depending upon the time of year, before adding a fresh layer. The smaller dredges should be brought in first, and should begin work simultaneously on each side of the proposed cut.

The larger dredges should be brought in last and should follow the smaller ones. They will not be absolutely required, except for the upper end of the cut, but could probably finish the lower end also better than the smaller ones. The cutting of the ridge with clam-shell dredges is a special problem. The exact method of construction will depend largely upon the time of year and the stage of the river and the basin, and may be quite different from that indicated here. It will probably be necessary during much of the time of working, to pump water continuously from the river at, or near Knights Landing, to keep the dredges afloat, and the estimate will provide for continuous pumping. If it is possible to do a portion of the work at the lower end of the cut, south of district No. 730, during the periods of high water in Yolo basin, it will save pumping expense, and will also save the excavation of a considerable amount of yardage in the estimates. This saving will result from the fact that it will not be necessary to dig the borrow pits 10 ft. deep in order to give the material for the required levees, at most points below district No. 730. Such possible saving, however, is dependent upon the

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season, and is not considered in making the estimates.

It is estimated that the two larger dredges will handle 75,000 cu. yd. per month and the two smaller dredges 50,000 cu. yd. per month, giving a total of 250,000 cu. yd. per month. At this rate the eastern alignment will require about 12½ months, and the western alignment about 18 months for completion. As the large dredges, however, cannot start until one or two months after the smaller dredges, it is safe to estimate that the eastern alignment could be completed in 14 months, and the western alignment in 20 months. The width of the right of way consists of the channel cut itself, plus the width of two berms, and two spoil banks or levees. With a fixed effective cross-sectional area of 6250 sq. ft. the width of right of way required ranges from about 700 to 900 feet.

The greatest width results from waste material removed from the cut at its deepest point. It is therefore determined that the right of way should be fixed at 900 ft. for the section through the crest of the Knight's Landing ridge and should taper to 750 ft. near the railroad track, which width should be maintained for the rest of the length.

ESTIMATED COST OF EASTERN ALIGNMENT (EXCLUSIVE OF RIGHTS OF WAY)

Excavation, 3,135,200 cu. yd. at 9c		$ 282,168
Accessories to dredging—		
Bringing dredges in from river	$ 4,000	
Pumping to keep dredges afloat	10,000	
		14,000
Alterations to drainage of district No. 730 (exclusive of cost of 20 acres of right of way)—		
Drainage and seepage ditches	$ 6,250	
Reinforced concrete siphon	8,000	
		14,250
Highway bridges—		
Main county road—trestle work, $9,000; 70-ft. lift span, $2,500	$11,500	
Four secondary bridges—trestle work, $22,100; 70-ft. lift spans, $7200.	29,300	
		40,800
Southern Pacific railroad crossing—		
Earthwork on approaches	$ 2,000	
Ballasting and track laying	1,000	
Shoo-fly	2,000	
Bridge—trestle work, $5,300; 70-ft. plate girder, movable span, $3,000	8,300	
		13,300
Clearing of rights of way—		
Inside district No. 730	$ 5,000	
Below district No. 730	8,000	
		13,000
Total		$377,518
Add 10% for administration, incidentals, and extras		37,752
		$415,270
Add 5% for engineering		20,763
Total		$436,033

WESTERN ALIGNMENT.—The estimated cost complete, exclusive of cost of right-of-way, of the western alignment is shown in the following table, No. 28:

ESTIMATED COST OF WESTERN ALIGNMENT (EXCLUSIVE OF RIGHTS OF WAY)

Excavation, 4,556,300 cu. yd. at 9c		$410,067
Accessories to dredging—		
Bringing dredges in from river	$ 4,000	
Pumping to keep dredges afloat	10,000	
		14,000
Highway bridges—		
Main county road—trestle work, $9,000; 70-ft. lift spans, $2,500	$11,500	
Four secondary bridges—trestle work, $22,100; 70-ft. lift spans, $7200.	29,300	
		40,800

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Southern Pacific railroad crossing—		
Earthwork on approaches	$ 2,000	
Ballasting and track laying	1,000	
Shoo-fly	2,000	
Bridge—trestle work, $5,300; 70-ft. plate girder, movable span, $3,000.	8,300	
		13,300
Clearing of rights of way—		
Inside district No. 730	$ 2,000	
Below district No. 730	8,000	
		10,000
Bank protection		2,000
Total		$490,167
Add 10% for administration, incidental, and extras		49,017
		$539,184
Add 5% for engineering		26,959
Total		$566,143

The entire district affected directly or remotely by the proposed cut includes most of Colusa basin and upper Yolo basin, and possibly to a limited extent, some of the territory across the river. This is to some extent a matter of judgment and is of course subject to modification by the Knight's Landing Ridge Committee, or whatever legislative body has the task of forming the district, and fixing the boundary lines. The territory outside of the proposed lines would be affected so infrequently and indirectly, that it is not included. The north boundary coincides with the north line of reclamation district No. 108. The territory north of this, in the Mormon basin and between district No. 108 and upper Sycamore slough is affected indirectly by any work which affects district No. 108, as it is in danger of being flooded whenever district No. 108 is submerged. The Mormon district, however, has its own levee system, and the balance of the land below Sycamore slough is relatively high.

Below Knight's Landing ridge, quarter mile lines are followed approximating the 38-ft. contour as far south as the limit of the work proposed by the Débris Commission along the limit of the Yolo by-pass and the Cache creek inlet. The eastern boundary line follows the Sacramento river, cutting off certain bends which are not leveed, from the proposed Fremont weir to the Colusa-Yolo county line, and from Colusa-Yolo line follows the boundary line of district No. 108. The levee lines along the banks of the proposed cut in the unreclaimed land below district No. 730 will make it easier to reclaim any portion of this land.

Particular care has been taken to include all of the land most directly affected. It will, of course, be left to the assessment commissioners to finally judge whether it is benefited or damaged thereby, and the extent to which it is affected. If in the judgment of the commissioners, portions of the land included in the proposed boundary lines are not directly affected, then such lands will not be compelled to meet any assessments. The approximate areas in the proposed district are shown in the following table:

AREAS DIRECTLY AFFECTED BY THE PROPOSED KNIGHT'S LANDING CUT

	Acres.	
Area inside of levees:		
District No. 108	51,000	
District No. 787	10,000	
District No. 730	4,500	
Total leveed area		65,500
Unleveed area:		
North of Knight's Landing ridge	21,000	
Below Knight's Landing ridge, west of proposed cut	5,000	
Below Knight's Landing ridge, east of proposed cut	3,000	
Total unleveed area		29,000
Total in proposed district		94,500

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Power Factor*

AN alternating current flowing in a circuit such as a wire, the windings of a transformer or of an induction motor, may be resolved into two components; one an energy component in phase with the electro-motive force applied to the circuit, the other displaced ninety degrees of phase from that electro-motive force and hence representing no consumption of energy and called wattless. This latter component is due to the induction of cables, transformers, induction motors, etc. The product of the current component in amperes by the impressed electro-motive force in volts gives respectively, volt-amperes energy and volt-amperes wattless; or, dividing by 1,000, gives kilovolt-amperes energy (kilowatts) and kilovolt-amperes wattless. The combination of both components gives the total kv-a., or apparent load. The ratio of energy component to the total $\left(\text{or } \frac{\text{kw.}}{\text{kva. (total)}}\right)$ is called the the power factor.

The power-factor of the current taken by constant potential transformers is high, practically 100% under normal load conditions; but is very low at no load, as then the magnetizing or wattless component of the current input becomes a large percentage of the total, the energy component representing only the iron and copper losses. The power-factor of an induction motor is relatively low even under load conditions, due to the air-gap in the magnetic circuit which necessitates a large magnetizing current. At light loads the power-factor decreases considerably, being very low at no load. Constant current transformers for the operation of series lighting circuits, including the circuit, have a low power-factor when fully loaded and very low power-factors at light loads due to the method of regulation. The most important cause of low power-factor is the induction motor. The tendency of the times is toward individual drives and small motors, and hence lower power-factors. The tendency should also be toward a careful study of each installation and a proper fitting of each motor to the work to be done, and hence a raising of power-factor due to fewer underloaded motors.

The low power-factor means large total currents; at 0.80 power-factor the total current for doing a certain work is 25% larger than would be the case with power factor 1. The heating of lines, transformers, generators, etc., is related to the square of the total current. The necessary capacity of apparatus to supply a certain amount of energy is inversely proportional to the power-factor. Lagging currents have an objectionable effect on the regulation of lines, transformers, and generators, greatly increasing the drop of voltage with load. An alternating generator of 8% regulation on a load of power-factor 1.0 will have a regulation of approximately 25% at 0.75 power-factor lagging. A transformer having a regulation of 2% on a load of power-factor 1.0 may have a regulation of 4% to 5% on a load of power-factor 0.75 lagging. A three-phase line delivering 1,000 kw. a distance of five miles over No. 0 wire at a delivery voltage of 6,000, will show the following voltage drops at various power-factors:

Power-factor 0.70; drop in % of delivered voltage 16.

Power-factor 0.80; drop in % of delivered voltage 14.

Power-factor 0.90; drop in % of delivered voltage 11.

Power-factor 1.00; drop in % of delivered voltage 7.

Thus the regulation at 0.7 power-factor is 45% greater or poorer than at power-factor 0.9 and 130% worse than at power-factor 1.00.

A generator to deliver 1,000 kw. at 0.7 power-factor must deliver 1,430 kv-a., and hence be nominally of 1,430 kw. capacity. This generator will require from 30% to 50% more current and 70% to 120% more kilowatts excitation (depending on the type of generator), to maintain the bus voltage with 1,000 kw. load at 0.7 power-factor (i. e., 1,430 kv-a.), than for 1,430 kv-a. at 1.0 power-factor. This heavy excitation means increased heating in the generator fields; and it is frequently found that this heating, or the limitations of the exciting system, impose a limit on the generator output. The prime-mover driving this generator need be equivalent to only 1,000 kw. energy output instead of to 1,430 kw. energy output. If the generating units in a station supplying the above load are of 500 kw. capacity at 1.0 power-factor, and the prime movers are

* Abstract from General Electric Review, July 1912.

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sufficiently large to drive the generators at full-rating energy load and overloads, then it will be necessary to operate three units to carry 1,430 kv-a., whereas there is only sufficient load for two prime movers, i. e., 1,000 kw. If the units are each of 1,000 kw. capacity, 1.0 power-factor, then two must operate on energy load sufficient for the economical operation of but one. It will thus be seen that low power-factor results in increased losses in lines and apparatus; poorer regulation in lines and apparatus; wasted capacity in lines and apparatus; wasted capacity in exciting system; a discrepancy between the capacity of generator and its prime mover.

Respecting Water Powers*

By A. V. WHITE

WHEN the knowledge of the quantities of water-power that may be available in particular places is required on short notice, and when sufficient records of actual observations do not exist, it is possible to estimate the probable amounts of power available. For such preliminary estimates, data are secured by what may be termed a reconnaissance survey of the general situation; but it must be recognized that the conclusions reached by such methods are not comparable with the results deducible from actual observations of individual water-power conditions extending over a series of years. It will be profitable to explain, very briefly, these reconnaissance methods for estimating water-power. First, the area of the watershed in question is ascertained by measurement from the best available maps; to this area is applied an assumed run-off coefficient such as would be suggested by a general knowledge of the precipitation, and of the topography, and other characteristics of the territories involved. The wise choice of the coefficient used will, of course, depend upon the good judgment and knowledge possessed by the engineer. This run-off coefficient, as it is termed, is a quantity which represents the amount of water that may be drained off any specified area during a stated period, and is usually expressed as so many cubic feet per second per square mile. Obviously, if the area of the watershed is known to be so many square miles, and each square mile, under specified conditions, will yield so much water, then the total yield of water from the whole watershed will be the product of the factors just mentioned.

When the discharge of a stream, or river, is actually measured, it is usually accomplished by means of floats, or by using a current-meter. The principles involved are very simple. They consist essentially of measuring the velocity of the flow of the stream by means of floats, or meter, and measuring also the area of the cross-section of the river at the place for which the velocity has been thus obtained. The volume of the water which passes a given point is the product of the area of the cross-section of the stream and the velocity of flow at that point.

A concrete illustration will make these methods of estimating clearer. Take, for example, the case of a water-power like Healey falls, on the Trent river, Ontario. The fall is here considered to have an effective head of 60 ft., and we will further suppose that it is desired to ascertain the horse-power available at low water. From the map of the district it would be ascertained, by measurement, that the drainage area above the fall is about 3630 square miles. If the engineer had previously ascertained that the run-off in some other similar territory was 0.4 cu. ft. per second per square mile, he would use this coefficient and thus obtain an estimated run-off, or discharge, of 1452 cu. ft. of water per second (3630 sq. mi. × 0.4). Assuming water-wheels of 80% efficiency, this 1452 cu. ft. of water per second, with a fall of 60 ft., would give approximately 8000 hp. If actual, yet insufficient, discharge measurements were made at Healey falls, such data would be criticized by the engineers according to the time of the year at which they were made, etc., in order to deduce what the Trent river would discharge at its lowest stage; and this quantity, so derived, would then serve as a check upon

*Abstract from *Applied Science*, December 1912.

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the flow estimated by means of the previously assumed run-off coefficient and drainage area.

The theoretical horse-power available at any point on a stream is the product of the effective height through which the water falls, and the weight of the water falling in a given time. Thus:

Let Q represent the flow of water in cu. ft. per second

h represent the effective fall in feet

Horse-power $\frac{5\,Qh}{44}$

Considering a good turbine to develop 80% of the theoretical power, we have

Horse-power $\frac{Qh}{11}$

Hence, a simple rule for estimating the horse-power that may be developed under favorable conditions is: *Multiply the flow in cu. ft. per second (Q) by the effective head in feet (h), and divide the result by 11.* It must not be forgotten that, in order to state in a reliable manner the power available for any place, it is necessary to give the stage of the river (namely, the height of the surface of the river with respect to a zero or bench-mark), at which the amount of power stated may be produced.

Floats

When floats are utilized for the direct measurement of the velocity of streams, those in common use are surface, sub-surface, and tube or rod-floats.

Sub-surface Floats.—The sub-surface float is designed to measure velocities below the surface and may be made to float to any depth. By arranging the submerged float at the depth of mean velocity, it may be utilized in observing mean velocity directly. Allowance must be made, however, for the accelerating effect of the attached line and surface float.

Tube or Rod Floats.—The tube or rod float is designed to measure directly the mean velocity in a vertical. It is generally a cylinder of tin, about 2½ in. diameter, weighted at its lower end and plugged with wood or cork at its top. Small extra weights to make it float at the exact depth desired may readily be added by admitting water or by putting in shot. The tube should be graduated and alternate feet painted black and red in order that the depth of the flotation may readily be observed. A number of tubes of different lengths are necessary for measuring the velocity of different depths in an ordinary cross-section. A float of this type, consequently, is best adapted for use in artificial channels in which the depth is nearly uniform. Natural channels are generally too rough and too variable to permit of satisfactory use. In field-work, where it appears expedient to employ rod floats, these may be improvised by using dry saplings, cut to suitable lengths and weighted with stones tied to their lower ends. Although designed to measure directly the mean velocity in a vertical, the tube cannot be made to float in contact with the bed of the stream, and consequently it does not receive the effect of the slowest-moving water. The rougher the bed the greater the error in this respect. A factor less than unity is, therefore, necessary to reduce the observed velocity to the mean.

Although the method of determining the discharge of streams with floats[1] is not usually so convenient, or simple, as with the current-meter, it is, however, less expensive, and for all practical purposes, especially in reconnaissance work, the results are quite as good as those obtained with the current-meter, provided the measurements are not to be used in conjunction with daily gauge heights in order to determine the daily discharge. To determine the discharge by means of floats, select a straight course along the stream in question, the length of the course being, roughly, about twice the width of the stream. The cross-section throughout this course, and for a short distance above and below it, should be as uniform as possible, and the bottom should be as smooth as possible and free from all large projections. Rather than run floats over bad reaches in the stream, it is preferable to shorten the course, although it is rarely desirable to take a course less than 50 ft. in length, unless the stream is less than 10 to 20 ft. wide.

At the upper end of the course set two rods, rod 1 on the river bank, and rod 2 about 50 to 100 ft. back from the river, so that a line through them will be, as nearly

[1]The data respecting stream measurement by surface floats, here given, have been furnished as a result of special research made by R. H. Bolster, and have been made available for present purposes by the courtesy of M. O. Leighton, Chief Hydrographer of the United States Geological Survey.

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as possible, at right angles to the direction of the stream over the selected course. Carefully measure the distance from rod 1, nearest the river, to the lower end of the course, and there place rod 3 at an equal distance back from the river. Going next back from rod 3 the same distance (measured) that rod 2 is from rod 1, place rod 4, which should be exactly the same distance from rod 2 as rod 1 is from rod 3. (Note.—In very narrow streams, rods 2 and 4 can frequently be dispensed with, but in wide streams they should always be used.)

Have an assistant loosen floats,[2] consisting of small blocks of wood (weighted, if necessary, to avoid wind effect on the surface above the water), a short distance above the upper end of the course, spacing them across the stream at intervals of about one-tenth the width of the river. Sight past rods 2 and 1 and note with a stop-watch,[3] or an ordinary watch, the time when a float passes the upper end of the course. Go to the lower end of the course and similarly note the passage of the same float past staffs 3 and 4. The average of time the float runs, divided into the distance apart of the upper and lower ends of the course, will give the average surface velocity in feet per second.

Determine four cross-sectional areas (or more, if desired), situated at ⅛, ⅜, ⅝, and ⅞ the distance between the upper and lower ends of the course. Stretch a tagged telegraph wire, measured cord, or steel tape across the river at the points indicated, and, at regular intervals, take soundings, recording them as indicated in the table below. Ten sounding points, equally spaced, should ordinarily be sufficient.

Cross-section One-eighth Below Upper End of Course

Station.	Depth, ft.	Width, ft.	Mean Depth, ft.	Area, sq. ft.
12	0.0	..	..	...
20	1.1	8	0.6	4.8
30	4.3	10	2.7	27.0
40	5.6	10	5.0	50.0
50	6.3	10	6.0	60.0
60	7.6	10	7.0	70.0
70	7.0	10	7.3	73.0
80	6.1	10	6.6	66.0
90	5.3	10	5.7	57.0
100	4.0	10	4.6	46.0
110	2.1	10	3.0	30.0
117	0.0	7	1.0	7.0
Total area				491.0

Total area at:	Ft.
⅛ point	491
⅜ point (here assumed to be).....	500
⅝ point (here assumed to be).....	458
⅞ point (here assumed to be).....	511
Total	1960

Average cross-section, 490 sq. ft.

The average of the four areas can be taken as the average cross-sectional area of the course. The soundings can be made by wading the section with a graduated rod, or from a boat with graduated rod, or with weight on the end of a graduated cord, if too deep for wading. The tagged wire can be used to hold the boat in position. The mean surface velocity (ft. per second) × the mean cross-sectional area (sq. ft.) × a constant K = the discharge of the stream in cu. ft. per second. The constant K varies quite widely under different channel conditions, ranging from a minimum of about 0.70 to a maximum of about 0.90 or more. In general, K can be said to vary inversely as the slope (or velocity), inversely as the roughness, directly as the depth, and indirectly as the width (for narrow streams).

The following table will serve as an approximate guide in the determination of the most probable coefficient K. Interpolate for conditions not given in the table.

The coefficient close to abutments, or piers, usually lies between 0.90 and 1.00, and is often greater than unity. Similarly for channels with rectangular sides and a width not greater than about three times the average depth, the coefficient is likely to be higher than 0.90 and sometimes greater than unity.

Convenient Equivalents

The following is a list of convenient equivalents for use in hydraulic computations:

In British Columbia, under the 'Water Clauses Consolidation Act, 1897,' section 143,

[2]A corked-bottle float, with a flag in the top and a weight in the bottom, makes a very satisfactory surface float, as it is but little affected by the wind. In flood measurements, good results can be obtained by observing the velocity of débris or of floating cakes of ice.

[3]Stop-watches are necessary for the satisfactory observation of velocity by floats, and for integration by meters. They are recommended for use in all meter work.

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Velocity, ft. per sec.	Average Depth, ft.	Size of Material on Bottom, ft.	Coefficient.
2 or less	2 or less	½ or less	0.80 to 0.85
2 or less	2 or less	1	0.75 to 0.80
5	2 or less	½	0.80
5	2 or less	1	0.75
10 or more	2 or less	½	0.75
10 or more	2 or less	1	0.70
2 or less	5	½ or less	0.85 to 0.90
2 or less	5	1	0.85
2 or less	5	3 or more	0.85
5	5	½ or less	0.85
5	5	1	0.85
5	5	3 or more	0.80 to 0.85
10 or more	5	½ or less	0.80 to 0.85
10 or more	5	1	0.80
10 or more	5	3 or more	0.80
2 or less	15	½	0.90
2 or less	15	1	0.90
2 or less	15	3 or more	0.90
5	15	½	0.90
5	15	1	0.90
5	15	3 or more	0.85 to 0.90
10 or more	15	½	0.90
10 or more	15	1	0.85 to 0.90
10 or more	15	3 or more	0.85 to 0.90

1 miner's inch was declared to be a flow of water equal to 1.68 cu. ft. per minute. Therefore, 1 miner's inch = 0.028 cu. ft. per sec., and 1 cu. ft. per sec. = 35.7143 miner's inches, approximately.

A flow of 1 miner's inch per second = 0.1745 imperial gal. per sec.

1 sec.-ft. = 40 California miner's inches (law of March 23, 1901).

1 sec.-ft. = 38.4 Colorado miner's inches.

1 sec.-ft. = 40 Arizona miner's inches.

1 sec.-ft. = 7.48 U. S. gallons per second.

1 sec.-ft. = 6.2321 imperial (British) gallons per second.

1 sec.-ft. for one year covers 1 sq. mi. 1.131 ft., or 13.572 in., deep.

1 sec.-ft. for one year equals 31,536,000 cu. ft.

1 sec.-ft. equals about 1 acre-inch per hour.

1 sec.-ft. for one day covers 1 sq. mi. 0.03719 in. deep.

1 sec.-ft. for one 28-day month covers 1 sq. mi. 1.041 in. deep.

1 sec.-ft. for one 29-day month covers 1 sq. mi. 1.079 in. deep.

1 sec.-ft. for one 30-day month covers 1 sq. mi. 1.116 in. deep.

1 sec.-ft. for one 31-day month covers 1 sq. mi. 1.153 in. deep.

1 sec.-ft. for one day equals 1.983 acre-feet.

1 sec.-ft. for one 28-day month equals 55.54 acre-feet.

1 sec.-ft. for one 29-day month equals 57.52 acre-feet.

1 sec.-ft. for one 30-day month equals 59.50 acre-feet.

1 sec.-ft. for one 31-day month equals 61.49 acre-feet.

1 in. deep on 1 sq. mi. equals 2,323,200 cu. ft.

1 in. deep on 1 sq. mi. equals 0.0737 sec.-ft. per year.

1 ft. deep on 1 sq. mi. equals 0.88 sec-ft. per year.

1 mile equals 5280 ft.

1 acre equals 43,560 sq. ft.

1 acre equals 209 ft. square, nearly.

1 cu. ft. of water weighs about 62.5 lb.

1 hp. equals 550 ft.-lb. per second.

1 hp. equals 746 watts.

1 hp. equals 1 sec.-ft. falling 8.80 ft.

1⅓ hp. equal about 1 kw.

To calculate water-power quickly:

$$\frac{\text{Sec.-ft.} \times \text{fall in feet}}{11} = \text{net horse-power on}$$

water-wheel realizing 80% of theoretical power.

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Cost of Concrete on Country Roads*

By C. A. THOMAS and T. F. HICKERSON

THE cost of concrete in small structures on country roads will vary somewhat from its cost in town or on large jobs. A main point of difference is probably in the cost of materials delivered on the job. Another difference comes in the delay and expense of continually moving the plant from one point to another. The cost of hauling material to the work will be near 30c per cubic yard for every mile it must be hauled. An ordinary wide tread, slat bottom wagon bed containing a cubic yard is 38 in. by 8 ft. 6 in. by 12 in., inside dimensions, and is usually as much as the average team can handle over bad roads. An inch added to the height of the side boards increases the capacity of the bed .083 cubic yard. Loading sand or gravel into a wagon bed will cost from 7c to 10c per cubic yard where shovels are kept busy, but may cost as high as 15c when the driver loads his own wagon.

A small gang with four good men mixing and one man shoveling material into barrows and putting on water, should mix and wheel 40 or 50 ft. from 8 to 10 batches or 6 to 8 cubic yards of 1:2½:5 concrete, assuming a batch contains one barrel (four bags) of cement. The cost of this mixing will vary from 80c to $1.15 per cubic yard. On small jobs where new forms are required, the cost of framing and erecting the forms will never be less than $12 to $15 per 1,000 ft. B. M. of lumber used, due to the large amount of cutting and fitting necessary. On larger jobs the cost may be reduced to $8 to $10 per 1,000 ft. B. M. These costs are much less when old forms are used. Lumber will cost from $22.50 to $30 per 1000 ft. B. M. Steel rods will cost from 1¾c. to 2¼c. per pound, delivered in most sections of the state.

The labor cost of bending and placing steel is about ½c. per pound. This will be increased slightly if many rods greater than ¾ in. diameter must be cut cold. The cost of excavating for foundations will vary from 50 to 80c. per cubic yard in dry earth and will generally vary between $1.50 and $3 per cubic yard where small puddle cofferdams not over 6 ft. deep must be built. Tearing down forms, finishing and cleaning up around the work will usually cost about 10c. per cublic yard of concrete. The cost of moving the plant from one job to another will usually be from $10 to $20, where the plant is not moved over five miles.

The cost data below is for a small 4 ft. by 5 ft. box culvert, 26 ft. long.

The work was done by a regular county concrete gang, composed of a foreman, seven men, and two teams with drivers, and was completed in four days of 10 hours each. The excavation was light, but the soil was of a hard, black nature that was hard trimming. Water for mixing had to be hauled two miles. Sand gravel was used for aggregate in the concrete. The gravel contained a slight excess of sand and worked up in the proportions given. Mixing was done by hand with negro labor. Twisted square steel bars were used for reinforcing.

LABOR.

Foreman, 40 hrs. @ 25c....	$ 10.00	
Culvert excavation, 9 cu. yds. @ 80c.....	7.20	
Labor on forms.....	14.00	
Mixing and placing, 120 hrs. @ 15c.....	18.00	
Hauling water, 20 hrs. @ 30c.	6.00	
Cutting and placing steel, 10 hrs. @ 15c.....	1.50	
Cleaning up and removing forms, 10 hrs. @ 15c.....	1.50	
	$ 58.20	
50% salvage on form lumber.	7.00	
	$ 51.20	
Moving on and off job.....	10.00	
Total labor at culvert....		$ 61.20

MATERIAL (laid down at culvert).

Cement, 26 bbls. @ $1.80....$	46.80
Hauling cement, 12½ hrs. @ 30c.	3.75
Gravel, 18½ cu. yds. @ $1.10 f. o. b. cars Ennis, Tex.....	20.35
Hauling, 18½ cu. yds. 46 hrs., @ 30c. (75c. per cu. yd.)..	13.80
Steel, 1,072 lbs. @ 2½c.....	26.80
Hauling steel, 2 hrs. @ 30c..	.60

* Abstract from Economic Paper No. 28, North Carolina Geological Survey.

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Lumber, 1,000 ft. B. M. @ $25.	25.00	
Hauling lumber, 3 hrs. @ 30c.	.90	
	$138.00	
75% salvage on form lumber.	18.75	
Total cost of material at job		119.25
Total cost of job.....		$180.45
Cost per cu. yd. of concrete in place exclusive of culvert excavation....		$9.37
Cost per cu. yd. of concrete in place exclusive of excavation and steel...		$7.85

The quantities were as follows: 14½ cu. yds. of 1:3:5 concrete; 4 cu. yds. of 1:2½:4 concrete; 432 lbs. of ¾ in. steel; 640 lbs. of ½ in. steel; and 1,000 ft. B. M. of lumber.

In estimating the cost of work it is well to use a form similar to that shown for the cost data above. When it is desired to find the probable cost per cubic yard of concrete, table given below is convenient. The various amounts of each material are determined and multiplied by their cost per cubic yard laid down at the job, these costs varying for almost every case. The other costs which are more nearly constant may then be added as shown below.

For example, if 30 cu. yds. of 1:2½:5 concrete is needed and the cost of material laid down at the job is given, its cost per cubic yard may be approximately estimated as follows:

Cement, 1.37 bbls. @ $1.50.....		$2.06
Sand, 0.48 cu. yd. @ $0.50.....		.24
Stone, 0.96 cu. yd. @ $0.50 to $1.50	$0.50 to	1.45
Mixing and placing.....		1.00
Forms (labor and material)...	.50 to	.75
Hauling material	.50 to	3.00
Foreman, moving, cleaning up, etc.		1.00
Plain concrete (per cu. yd.)..	$5.85 to	$9.50
Reinforcing steel (0.5% to 0.8%), 66 to 106 lb. @ 3c. per lb. in place	2.00 to	3.20
Reinforced con. per cu. yd....	$7.85 to	$12.75

It will be seen that the cost of hauling and the cost of stone or gravel will greatly influence the cost of the concrete.

Rules for Conducting Tests of Waterwheels

[The preliminary report of the power test committee of the American Society of Mechanical Engineers has been published in the November issue of the *Journal*. The subjects covered in the report include boilers, reciprocating steam engines, steam turbines, complete steam power plants, pumping machinery, complete pumping plants, compressors, blowers and fans, locomotives, gas producers, gas and oil engines, complete gas power plants, and waterwheels. The waterwheel code following will be of special interest to Western engineers.—EDITOR.]

WATERWHEEL tests may be divided into two classes, one of which may be termined 'shop' tests and the other 'field' tests. The former refer to those which are conducted in a plant devoted exclusively to testing work, and the latter to test of the wheel in its permanent location. The Holyoke Water Power Company's testing flume is an example of a shop-testing plant, being one which is equipped for turbine water wheels of any size up to 300 hp. at 18-ft. head. This plant, it is understood, is also the only one of the kind in the country which is available for commercial work. Under these circumstances there seems to be no call at the present time (1912) for a general code of rules applying to tests of that character. The tests to which the following code refers are therefore limited to field tests; the wheel being in place, and operating so far as possible under the conditions of service for which it was installed.

The usual object of a waterwheel test in the field is the determination of the capacity and efficiency of the wheel at various gate openings and, if practicable, at various speeds, as compared with standard or guaranteed performance. Having determined the object, whatever it may be, take the dimensions, note the physical condition of the wheel and of the plant throughout, install the testing appliances, etc.

The most important preparations are those which relate to the determination of the

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power developed by the wheel, and the quantity of water which it consumes. The nature of these preparations is governed altogether by the character of the equipment. As regards power determination, the simplest method is the one applying to a case where the wheel drives an electric generator and the power is measured by calculation from the electrical output. Another simple method is one which may be used where the wheel serves as an auxiliary to steam power, and the output is determined by ascertaining the difference between the indicated horse-power developed by the engine when the wheel is on and that developed when the wheel is off. Another method which is applicable to almost any situation where there is room, although the most difficult of the three, is the use of a friction brake attached to the waterwheel shaft, being arranged so as to take the place of a section of the shaft which may temporarily be removed. As to preparation for water measurement, the desirability of preserving the maximum head of water usually makes it necessary to gauge the stream supplied to the wheel or the stream leaving it, and to select or prepare for this purpose a sufficient length of canal having a uniform cross-section to determine the required velocity by float measurement. Another method consists in the use of current meters or pitometers which have been properly calibrated. In cases where some part of the head may be sacrificed either in the head race or tail race, the measurement may be made by the insertion of a suitable weir.

The apparatus and instruments required for a capacity and efficiency test of a waterwheel are:

(a) A friction brake, steam engine indicators, or electrical instruments, depending on the character of the equipment.

(b) Graduated scales showing the heights of water in the flume above the wheel and in the discharge pit beneath.

(c) One or more current meters or other apparatus for ascertaining the velocity of the water; or a weir.

It is of the greatest importance that the water measured is that which is consumed wholly by the wheel. If water leaks by without going through the wheel, the quantity of leakage should be determined by independent measurement when the wheel is entirely shut off; in which case the gross quantity is corrected accordingly.

The duration of a simple efficiency test of a waterwheel depends mainly upon the method of water measurement employed, and the time required to obtain a sufficient number of observations to insure a reliable average. After the desired load and other conditions have been obtained, continuous observations and measurements for a period of 15 minutes is sufficient for all practical purposes, provided the water is measured by a weir, but a longer time is necessary when other methods of measurement are used.

Readings of the weight on the brake arm, levels of water in the flume and discharge pit, indications of the current meters, and revolutions per minute, should be taken every five minutes, and at more frequent intervals if they show much fluctuation. In case of float measurement, repeated observations should be made one after the other throughout the whole period of the trial.

The total average head of water on the wheel is obtained by adding together the reading of the scale in the flume and the vertical distance between the zero of this scale and that of the scale in the discharge pit, and subtracting the reading of the latter scale, both readings being taken in reasonably still water.

The velocity of water in the measuring canal is found by averaging the readings obtained at several points extending over the whole width of the canal.

The cubic feet of water consumed per minute is obtained by multiplying the cross-section of the stream in square feet by the velocity of the water in feet per minute, determined as stated above.

The total power of water available is obtained by multiplying the net weight of water in pounds consumed per minute by the total average head in feet on the wheel, and dividing the product by 33,000.

The brake horse-power delivered by the wheel is found by multiplying the net weight on the brake arm in pounds by the circumference of the corresponding circle in feet and by the number of revolutions per minute, and dividing the final product by 33,000.

The data and results should be reported in accordance with the form given herewith, adding lines for data not provided for or omitting those not required, as may conform with the object in view:

(1) Test of.....water wheel located at..... to determine .....,

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conducted by.....
(2) Type of wheel and class of service .....
(3) Type of generator, if any, kind of current, etc. .....
(4) Rated power of wheel.....hp.
(5) Cross-section of stream where velocity of wheel is measured.....sq. ft.

GENERAL DATA

(6) Date .....
(7) Duration of period covered by test .....hr.
(8) Average net weight on brake arm..lb.
(9) Average revolutions per minute.r.p.m.
(10) Total average head of water on wheel .....ft.
(11) Average velocity of water per minute in measuring canal.....ft.
(12) Cu. ft. of water consumed per minute .....cu. ft.
(13) Weight of water consumed per minute (Line 12 by 62.35).....lb.
(14) Leakage per minute.....lb.
(15) Net water consumed per minute (Line 13—Line 15) .....lb.

POWER

(16) Total power of water available....hp.
(17) Brake horse-power delivered by wheel .....b.hp.

EFFICIENCY

(18) Efficiency of wheel (Line 17 ÷ by Line 16) .....per cent

Industrial Progress

The 'Calcite', a Self-Unloading Lake Steamer*

The lake steamers, carrying bulk cargoes, consume a considerable amount of time at the docks receiving and discharging their loads. The expense of this delay is consequently very heavy, especially on short runs, as it reduces the time available for actual transportation. The time consumed at the docks frequently amounts to as much as 50% of the ship's running time. The ordinary freighter also is limited to use between docks equipped with fast plants or equipment for automatically unloading the cargoes.

An interesting application of conveying machinery is made in the case of several lake steamers, which are equipped with conveyors for automatically discharging their cargoes. Such equipment provides for minimum loss of time and renders the boats entirely independent of the regular unloading stations.

Several years ago, the Stephens-Adamson Mfg. Co. equipped the steamers *Alpena* and *Wyandotte*, belonging to the Michigan Alkali Co. with unloading conveyors, which have proven a pronounced success both from a commercial and engineering standpoint. In 1910, they equipped a small fuel lighter with conveyors for the Pickands-Mather Co., of Cleveland. This boat is designed to discharge fuel to the lake steamers, when they are tied at the docks, or it can even steam out to passing steamers and supply them with fuel without hindering their progress.

The steamer *Calcite*, which is the subject of this article, is owned and operated by the Calcite Transportation Co., of Wyandotte, Michigan. The boat is now engaged in carrying crushed limestone from the calcite quarry of the Michigan Limestone & Chemical Co. to the docks of the Iroquois Furnace Co. at South Chicago, where it discharges entirely by means of its own equipment.

The length of this boat is 436 ft., its width is 54 ft., and it has a molded depth of 29 ft. On a draft of 19 ft., 6 in., the steamer carries 8300 net tons of limestone, which it can discharge by means of its own machinery, at a speed of over 900 tons per hour.

The general arrangement of the machinery on this boat is very similar to that on the *Alpena*, with the exception that the length of the *Calcite* is 60 ft. greater than the other boat and the conveyors in the hold are correspondingly longer. The boat, itself, is built on the lines of the ordinary lake cargo boat with engine and boilers situated at the extreme stern and the body of the boat covered with numerous wide hatchways. The cargo space is filled with a double row of hoppers, running lengthwise of the vessel and provided with gates below for regulating the discharge to the conveyors.

Beneath the openings in each row of hoppers, runs a 42-in. 'S-A' steel pan conveyor, 310 ft. between centres. These conveyors operate horizontally except at the discharge ends where they rise at an angle of 30° and

* Abstract from *The Labor Saver*, December, 1912.

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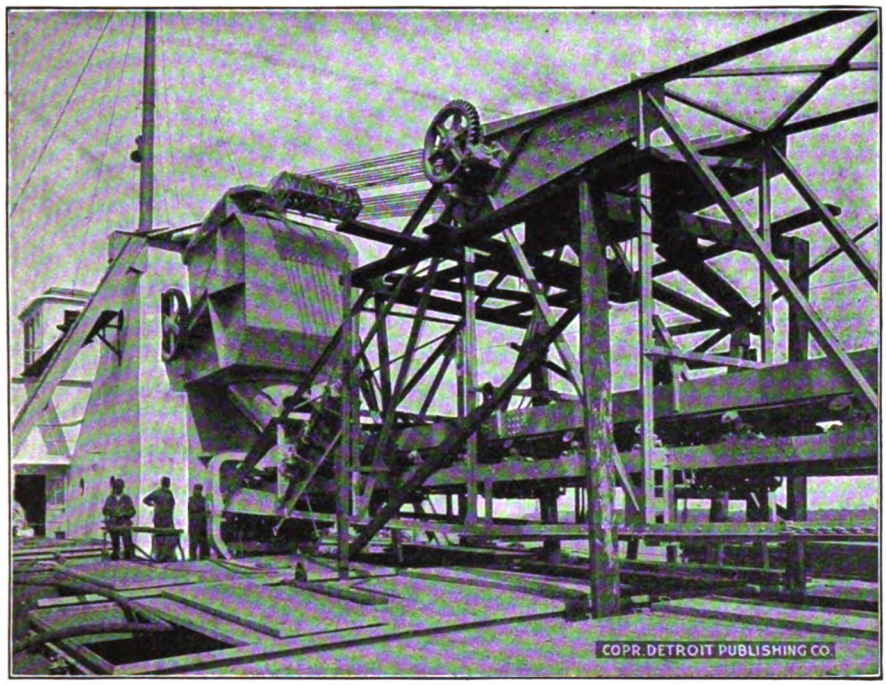
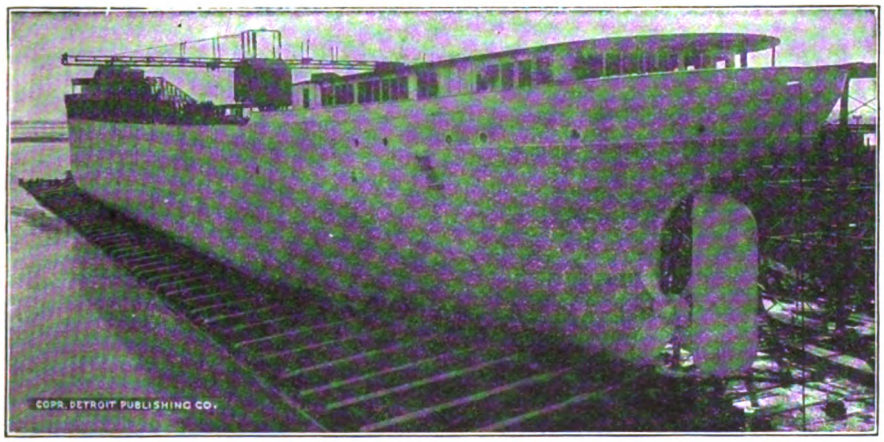
deliver to a chute feeding a 72-in. 'S-A' pan conveyor of the same type, but operating at a much steeper angle. This conveyor is situated centrally between the two hold conveyors and rises at an angle of 45° for a distance of 67 ft. between centres of end sprockets. From the head of this conveyor, the material is discharged to a hopper feeding a 48-in. by 90-ft. 'S-A' belt-conveyor, on a steel boom, arranged to swing out in either direction or to be raised or lowered as required. When not in use, the boom is swung toward the rear and rests upon the deck.



SHOWING CONTROL OF BOOM AND CHUTE DISCHARGING TO CONVEYOR.



'CALCITE' ON THE WAYS PREPARATORY TO LAUNCHING.

The type of the three steel pan conveyors is of the standard 'S-A' construction for conveyors of this type. The general construc-

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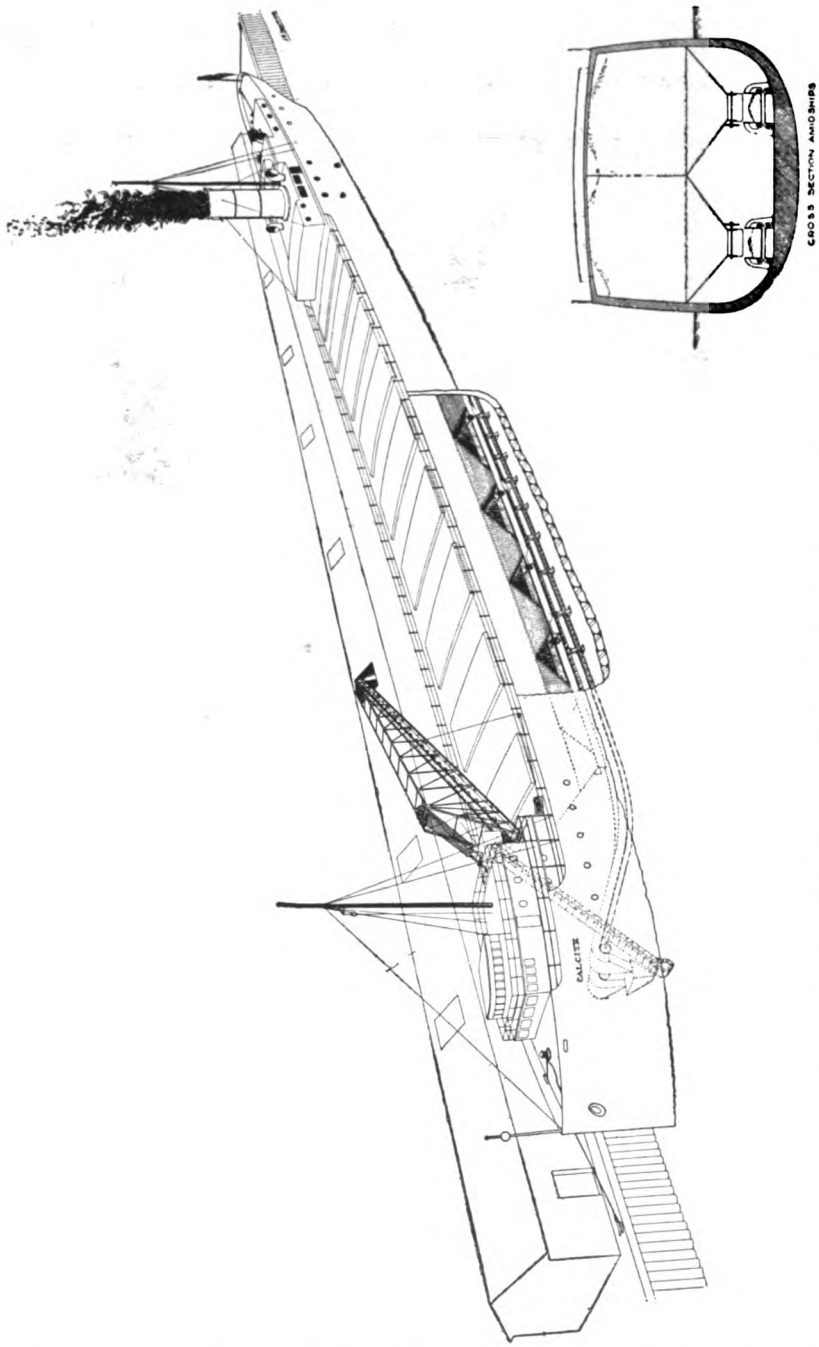

SHOWING GENERAL ARRANGMENT OF CONVEYORS AS THEY RECEIVE FROM THE HOPPERS AND DISCHARGE OVER THE SWINGING BOOM.

tion of the pans and chain is shown in the sectional cut, although the exact shape of the buckets varies somewhat according to the degree of incline of the conveyor. The pans are suspended between two steel bar roller chains, and carried upon steel shafts, which form the pins for the chains. The chains are of the standard 'S-A' steel bushed roller type. The rollers are self-lubricating and turn on steel bushings upon the pins. The bushings extend through the inner links to which they are keyed and the outer links

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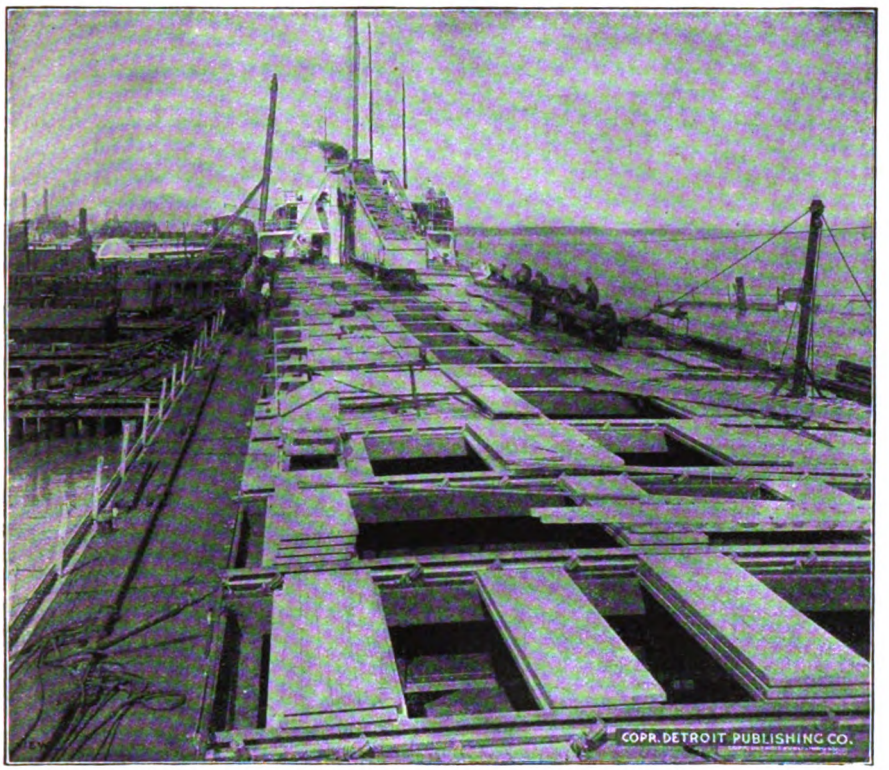
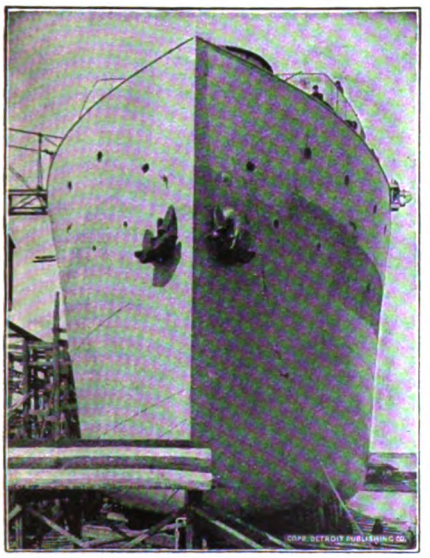
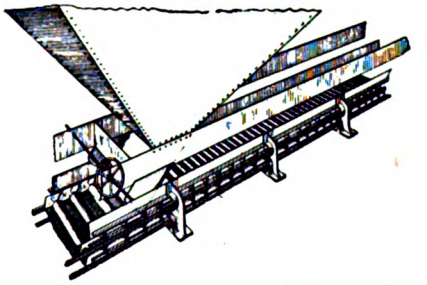


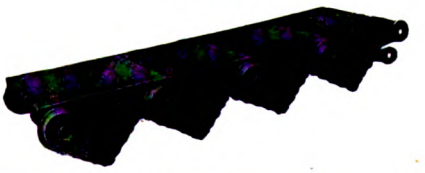
DECK VIEW OF 'CALCITE' AND UNLOADING BOOM.



BOW VIEW OF 'CALCITE' BEFORE LAUNCHING.



ONE OF THE HOPPERS AND THE GATE TO REGULATE THE DISCHARGE TO THE CONVEYOR.



SHOWING A SECTION OF STEEL PAN CONVEYOR OF THE TYPE USED.

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are keyed to the pin so that the stress in the chain is distributed over the entire bearing surface of the bushing. This type of chain and conveyor have proved particularly satisfactory where large capacity is required.

The power for driving the conveyors is secured from two horizontal compound engines, situated in the bow. One of these engines drives the two horizontal conveyors through a train of gears and the inclined conveyor and the boom conveyor are driven in the same way from the other engine. The boom conveyor is driven through a bevel gear and vertical shaft. The position of the boom is also regulated by the latter engine and controlled by heavy clutches. The two engines are loosely belted together so arranged that a belt tightener may be thrown in, allowing the engines to work together when necessary.

This boat was designed and built by the Detroit Shipbuilding Co., under the direction of Capt. D. R. Parsons, manager of the Calcite Transportation Co. The conveying equipment for this boat was designed by the Stephens-Adamson Board of Engineers and it was also manufactured and installed by this company. It was first put into commission in the early summer of 1912 and has since given regular and satisfactory service.

BOOM CONVEYOR AND S.S. 'CALCITE.'

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Discussion

Moisture in Compressed Air

The Editor:

Sir—Mr. Wallace, in his article on 'Moisture in Compressed Air,' in the October number, states that "The pressure of the mixture is the sum of the pressure of the pure dry air and pressure of the steam" and that "This relation is exactly true for a mixture of pure dry air and saturated steam." If this relation is exactly true, why is the atmospheric pressure less on a foggy day than on a clear day? On a foggy day the vapor pressure is greater than on a clear day, and if Dalton's laws hold exactly, the vapor will not displace any air and the atmospheric pressure will be greater than on a clear day, assuming the same temperature. What efficiency of cooling causes a water-jacketed compressor to give a compression curve above the adiabatic as stated at the top of page 542, second column?

GEORGE L. SULLIVAN.

[The above letter was referred to Mr. Wallace who was kind enough to furnish the following explanation.—EDITOR.]

Boulder, Colo., Dec. 28, 1912.

I am less certain in regard to the answer to Mr. Sullivan's first than his last question. However, I will say what I think on both. I will take up the second question first as it relates more to the subject of the original article, 'Moisture in Compressed Air.' The object of the water-jacket of an air-compressor is to extract heat from the air any time between its entrance and its discharge. The effect of the transfer of heat to or away from the air prior to the closure of the inlet valve cannot be shown on the chart. Inasmuch as the closure taken place practically at the beginning of compression we have under consideration the effect of heat exchange during the compression stroke. My statement taken from the original article is: "The curve of compression for water-jacketed compressors falls above or below the adiabatic curve depending on the efficiency of cooling." A curve entirely below the adiabatic is sought by means of the jacket; as much below as possible. A curve entirely above would be bad indeed. That a portion of curve will fall above and a portion below is true in a great many cases. Let us consider a case in which the temperature of the cooling water is the same as the temperature of the entering air. Some heat will radiate into the air in the cylinder during the suction stroke from the piston, the valves and other non-jacketed portions of the cylinder; and this process will not terminate until after compression has begun. While this is going on, the actual curve is rising above the adiabatic. Now the actual curve will become parallel to an adiabatic when the rate of heat absorption by the jacket is equal to the heat B.t.u. radiated by the unjacketed portions. When the total heat B.t.u. absorbed by the jacket is equal to the heat B.t.u. radiated by the unjacketed portions, the actual curve has returned to the adiabatic of the original temperature and volume. From now on the water-jacket is able to do good and place the actual curve below the adiabatic. The case just cited may obtain at some time within any 24 hours in any plant. In the winter season there are many cases in which the temperature of the entering air is below freezing while the temperature of the cooling water is above freezing. In such a case during the early portion of the compression stroke the water-jacket actually has a warming effect on the air in the cylinder. Relative to the question concerning fogs, several statements may be made. The conditions which effect atmospheric pressure, as recorded by a barometer, and the conditions which effect vapor pressure have no relation. The atmospheric pressure depends upon the density and height of the atmosphere where the pressure is recorded; the vapor pressure obeys the laws of steam. According to Regnault, and others who have experimented exhaustively on the relations between pressure and temperature of saturated water vapor, the pressure is definite for any definite temperature. On a foggy day we can be sure of a saturated vapor present, some pure dry air present, and some floating particles of water or snow are visible and contribute toward the barometric pressure in proportion to their weight and frequency. The vapor present is invisible but contributes to the barometric pressure a portion corresponding to the vapor pressure of the temperature existing. The pure dry air present is invisible, but contributes to the barometric pressure the remaining portion. Now there is not as much pure dry air present as on clear days of low absolute

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humidity. The vapor pressure in a boiling tea kettle with the lid off is equal to the barometric pressure. There are no visible particles of water present and no air present in the tea kettle. On a clear day the vapor present is not likely to be sufficient for a saturation. This would be revealed by the hygrometer. When there is more moisture present than necessary for saturation, the cloudy or foggy condition obtains. Clouds or fogs precipitate in the form of rain when they are shaken or the particles sufficiently bunched together. Saturated or partially saturated water vapor is transparent whether alone or mixed and will not affect the transparency of the admixed gases. In my article I referred to saturated vapor mixed with air and the statement is correct, namely, the vapor pressure will be the same for the same temperatures on clear or foggy days if the vapor is saturated. In the article, I needed to deal with saturated conditions only and temperature volume changes. When conditions of vapor pressure for partially saturated vapors arise such as obtain on most clear days we must follow the laws of superheated steam because a partially saturated vapor is nothing but superheated steam.

JACOB H. WALLACE.

Internal Combustion Engines

The Editor:

Sir—Referring to the article by J. W. White on 'The Internal-Combustion Engine in Central-Station Service' appearing in your November issue, I would like to offer the following criticism, in order that erroneous impressions may not be given to those not fully informed regarding the latest developments in Diesel-engine practice.

1. "Kerosene, distillates, and oil from 28 gravity down, form about 40% of the total volume of crude oil, and about 92% of refined fuel, and must necessarily constitute the fuel-supply for the internal-combustion engine of the future."

This is a very narrow limitation of the vast supplies available and suitable for the internal-combustion engine. For gas-engines, the waste gases from iron blast-furnaces, coke-oven operations, and gas generated from charcoal, peat, lignite, bituminous and anthracite coals in producers, are available. For Diesel engines, coal tar and its distillates, tar oils, products from coking and gas-works operations, which formerly were largely a waste product, are available, and will be available in increasing amounts. These tar fuels will constitute as important a fuel supply for stationary Diesel-engine plants as crude oils and their residues.

2. "The Diesel type of engine can use oils as low as 22 gravity, which are burned directly in the cylinder."

This statement is correct as far as it goes, but is misleading in that it does not go far enough. Oils as low as 14 gravity Baumé are regularly used in Diesel engines, and asphaltic oils and their residues now form an important supply of cheap fuels for the Diesel engine, and no "special refined fuel oil" is required for Diesel-engine use. Therefore, the same oil that Mr. White proposes to gasify in a producer to furnish gas for use in a gas-engine, can be used equally well direct in the cylinder of a Diesel engine.

3. Mr. White assumes the following efficiencies:

Steam plant of 1000-kw. capacity	10.5%
Diesel-engine plant	29.0%
Oil gas producer plant	20.0%

These efficiencies are too low for the steam plant and the Diesel plant, and too high for the oil gas-producer engine-plant. In best gas-engine practice, a commercial efficiency of 27% can ordinarily be obtained for the engine, and for a producer gasifying oil residues or crude oils, 50% efficiency is good work in actual practice. This would give a combined efficiency for the complete unit of $0.50 \times 0{,}27$, or 13.50%. In producers working on anthracite coal and coke, an efficiency of 70% is considered excellent work, and is higher than is ordinarily secured, so that even in this case an ultimate efficiency of 19% is high—a figure that has never been reached in continuous operation with an oil gas-producer and gas-engine plant. Working tests with an Ahmet oil gas-producer and a 1500-hp. Nürnberg gas-engine built by Allis-Chalmers Co., an installation in operation near Los Angeles, show an average oil consumption of 1 lb. per brake-horse-power hour, which, with oil of 18,000 B.t.u. per lb., would indicate an efficiency of not quite 14%, which figure agrees closely with well recognized and established practice, and is the efficiency at which I have arrived for such a plant as mentioned above.

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An efficiency of 12% should be obtained in a well managed and properly equipped steam plant of 1000-kw. capacity, which is the size Mr. White used as a basis for his comparisons. The Diesel-engine plant, if properly designed and equipped, and in charge of competent operators, should have not less than 33% efficiency when using four-cycle engines, and 31% when using two-cycle engines.

It is at once evident that, even assuming Mr. White's figures of $125 and $150 as the cost per kilowatt installed for the crude-oil producer and gas-engine plant and the Diesel-engine plant to be correct, it would be a technical incongruity to gasify oil first in a generator and then burn the gas in a gas-engine with an efficiency but slightly greater than that obtained in a steam plant, at a higher initial cost of installation and consequently larger capital charges, as well as higher operating and maintenance expense, than obtains in a steam plant, when this same oil can be burned direct in a Diesel-engine cylinder. A Diesel-engine installation would be the logical plant when 1000 kw. is the ultimate capacity. This fact is well recognized abroad, where gas producers, suction gas producers, and gas-engine plants are installed only where cheap and inferior coals are available, when the price of liquid fuels is prohibitive, or where natural gas or waste gas from blast-furnaces or coke-ovens are available for direct use in gas-engines. In Germany, Diesel-engine plants are preferred to steam plants for installations up to 1000-kw. capacity, where the relative cost of coal to liquid fuel is as low as 1 to 5, unless some special conditions favor the steam plant, as in some cases where the exhaust steam or condenser circulating water are used for heating purposes; but no one would give the oil-producer suction gas-engine plant consideration, for the above-stated reasons. It is not necessary here to refute the incorrectness of Mr. White's conclusions and cost curves per kilowatt-hour of generated energy. A simple consideration of the fuel cost based on the above corrected thermo-dynamic efficiencies of the different plants will demonstrate without much labored figuring that cost-curves per kilowatt-hour of a 1000-kw. Diesel-engine plant and a steam-turbine plant of the same size will not cross each other "at 75% load-factor." If the two curves cross at all, it will be at a very much lower load-factor. Nor would the cost-curve of the oil-producer and gas-engine plant be as favorable as that of the steam-turbine plant.

We have the following efficiencies:

Steam plant (1000 kw.) 12.0%
Oil-producer and gas-engine plant 13.5%
Diesel-engine plant, 4-cycle engines ... 33.0%

Using as a basis for figuring the cost of fuel value, an oil or residue having an average of 6,000,000 B.t.u. per bbl. of 330 lb., and assuming it to cost the unit price of $1, we obtain an absolute fuel cost of 1.667c. per 100,000 B.t.u. The fuel cost of 100,000 B.t.u. converted into effective work

$$\text{or b.-hp.} = \frac{\text{thermo-dynamic efficiency}}{\text{absolute fuel cost per 100,000 B.t.u.}}$$

and the fuel cost per b.-hp. hour is:

$$\frac{\text{absolute fuel cost for 100,000 B.t.u.} \times 2545}{\text{thermo-dynamic efficiency} \times 100{,}000}$$

We therefore obtain the following figures:

	Fuel cost for 100,000 B.t.u. converted into effective work, in cents	Fuel cost per b.-hp. hour, in cents
Steam plant	13.9	0.354
Diesel plant	5.05	0.129
Oil-producer gas-engine plant	12.3	0.314

The above figures are based on oil costing $1 per bbl. of 6,000,000 B.t.u. To alter the above figures to suit cheaper oil per barrel, multiply by the respective cost in cents and divide by 100; thus, with 60c. oil, the above figures becomes 60/100 of the above, and with $2 oil, 200/100 of the above, etc.

A comparison of fuel costs on a basis of 100,000 B.t.u. heating value of the fuel converted into effective work is the only one permissible furnishing a true index of the economic fuel value of the large variety of fuels available for power purposes; fuels varying widely in heating value and the ultimate efficiency secured with different prime-movers being also a varying quantity depending on the kind of prime-mover used and the size of the plant. Thus we may

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have coals with a heating value of 11,500 to 13,500 B.t.u. per pound, bituminous coals with a heating value of 9000 to 10,000 B.t.u., lignites with 3500 to 5000, peat briquettes with 5000 to 7000 B.t.u., coal, tars, and tar oils with 16,000 to 17,500 B.t.u. per pound, all differing in price; but by reducing all the fuel costs to a common basis of 100,000 B.t.u., which is the absolute fuel cost, and figuring the cost of the fuel value per 100,000 B.t.u. of the different fuels converted into effective work, we secure figures reduced to a uniform basis of comparison which show at a glance the relative economy secured with different fuels and different types of prime-movers and power-plants.

In conclusion, it is well to refer to a paper by M. Gercke, the chief engineer of the Augsburg-Nürnberg Machine Works, read before the Association of Electric Power Companies at Kiel, June 12, 1912. As that company is not only the largest builder of Diesel engines, having built upward of 350,000 hp. in Diesel engines alone, but is the most extensive European builder of gas-engines and steam turbines as well, Mr. Gercke's statements and conclusions are not colored, but can be accepted as authoritative and disinterested, being based on extensive operating data and costs obtained in different power-plants equipped with each type of prime-mover:

1. "If today a new central power-plant of small capacity is to be built, namely, up to about 1000 hp., then the Diesel engine is, under normal conditions, the most preferable prime-mover, provided that on account of peculiar and special conditions a reciprocating steam-engine is not to be preferred. Steam turbines cannot be recommended for such small installations."

2. "In medium-sized central power-plants, which comprise those with 1000 to 6000 hp. total output, the steam turbine will in many cases be economically superior to the Diesel engine; in *large* central power-stations, with units above 6000 hp. (4000 kw.), the steam turbine is decidedly superior economically to the Diesel engine. There is nothing to prevent, however, large Diesel-engine units from proving, even for medium and large-size central electric power-stations, to be an exceptionally valuable prime-mover alongside and in conjunction with the steam turbine."

HERBERT HAAS.

San Francisco, January 20th.

The Union Oil Co. Sale

The Editor:

Sir—I read your report in the December number of *Western Engineering* regarding the sale and transfer of the Union Oil Co.'s stock and holdings. Your article is misleading and you must be misinformed as to the actual conditions, which are that the Stewarts, who held a controlling interest in the Union Oil Provident Co., sold their stock to this company, and that the Provident controls the Union Oil Co. management, but has nothing to do with its property. The security of the Provident is secondary to that of the Union Oil stock holdings, as the Union Oil Co. owns all the properties, which were not in any way transferred with the stock of the Provident the Stewarts sold. This has been stated both by Mr. Lyman Stewart and by Mr. Watchorn, too, I think.

W. D. TURNER.

Pasadena, California, January 7th.

[The editorial in question is perhaps technically misleading, but is not as far as results are concerned. There are two holding companies which own Union Oil stock, one the Union Provident Co. and the other the United Petroleum Co. Of these, the former is controlled by the Stewart family and in turn controls, we understand, a majority of the stock of the Union Oil Co. The stock actually sold through Mr. Watchorn as intermediary, was the majority control of the Union Provident Co. owned by the Stewarts. The holding company idea is merely one of those tricks of financial legerdemain devised primarily for the purpose of enabling a minority interest to control a majority. To all intents and purposes the control of the Union Oil Co. will have passed to the General Petroleum Co. when all payments have been made according to the terms of the sale. —EDITOR.]

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Engineering Bonds

*Tax exempt in California.
†Legal investment for savings banks in California.
‡Available as security for deposit of state, county, and municipal funds and postal savings deposits.

BY a vote of 322 to 40, the issue of $400,000 bonds to complete the laterals and some of the district work of the Oakdale Irrigation District has been carried. The original bond issue was $1,000,000, and this election increased the bonded indebtedness of the district of 70,000 acres to $2,000,000.

THE PACIFIC ELECTRIC RAILWAY CO. has applied to the Railroad Commission for authority to issue refunding mortgage 50-year gold bonds to the amount of $7,034,000. The application states that the company proposes to apply the proceeds from the sale of the bonds to the following improvements, which are already under way:

Extensions and branches	$3,428,518.36
Additional main tracks	43,567.53
Tunnels, bridges, etc	444,609.81
Real estate	39,975.22
Stations, shops, etc	156,787.54
Light and power plants	216,962.27
Water and water rights	940.00
Rolling stock	1,554,911.23
Additions and betterments	699,410.08
Total	$6,585,682.04

Against this amount the company has already issued bonds to the amount of $930,348.28, leaving a balance against which it now desires to issue bonds to the amount of $5,655,333.84. The company desires also to issue bonds against new work which has been projected but not yet begun, as follows:

Construction	$ 530,940
Equipment	117,160
Additions and betterments	1,076,130
Total	$1,724,230

The projected improvements cover the principal lines of the Pacific Electric Railway Co. in southern California. The larger items enumerated in the application are as follows: Improvements to Covina-San Dimas line, $53,000; Riverside-Colton-San Bernardino line, $408,000; Glendale-Burbank line, $53,000; Lankershim extension, $236,000; Magnolia avenue line, $76,000; Pasadena city lines, $97,000; San Bernardino extension, $1,424,000; Van Nuys extension, $42,000; Dominguez Town Site line, $46,000; San Pedro-Hermosillo line, $42,000; Torrance line, $42,000; Van Nuys-San Fernando line, $213,000; Van Nuys-Owensmouth, $215,000; Watts-Homeward line, $108,000; Santa Ana-Orange line, $64,000; South Pasadena cut-off, $159,000; tunnels, bridges, etc., $444,000; stations, shops, etc., $156,000; Redlands-San Bernardino line, $105,000; Alamitos-Bay City line, $24,000; Covina line, $34,000; Gardena-Strawberry Park line, $17,000; Hawthorne-El Segundo line, $161,000; Pasadena local lines, $40,000; Santa Ana line, $76,000; Uplands-San Antonio line, $25,000; Del Rey-Redondo line, $87,000; Hermosa Beach line, $44,000; Redondo Beach, $175,000; Whittier-La Habra line, $105,000.

THE following is a summary of proposed bond issues to be submitted to the voters of Los Angeles for ratification:

1.—$1,500,000 for the construction of the Los Angeles city trunk line from the end of the aqueduct, through Franklin canyon, to join the present system in the vicinity of Wilshire boulevard and Western avenue. This line will bring at least 2000 inches to the city, will serve the Providencia district in the San Fernando valley, and carry the necessary supply for the territory to the west and southwest of the city. This line, if possible, must be in commission by the middle of the summer or a severe shortage of water within the city limits may be suffered.

2.—$2,500,000 to commence the construction of the Pasadena-Glendora-San Dimas high line which has already been described.

3.—$2,000,000 for constructing the distributing system for those portions of the San Fernando valley not covered by the high line of the Los Angeles city trunk line.

All these issues provide that the money may be used, not only for the actual construction of lines, but for securing such rights-of-way and reservoir sites as may be necessary.

SAN MATEO county will vote Tuesday, April 1, on the proposal to bond the county for $1,200,000 for a chain of highways. The bond issue provides for building 150 miles of asphaltum and macadam roads through the coast-side mountain district and a chain of highways interlacing El Camino Real.

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Book Reviews

RAILWAY ECONOMICS. The Bureau of Railway Economics, Washington. A collective catalogue of books in fourteen American libraries. Printed by the University of Chicago Press, May 1912. P. 445.

*During recent years in the United States of America there has been much investigation and discussion of railways on their economic side. The causes for this are to be found in the unsatisfactory conditions in railway affairs, rates, financial management, relations with employees, etc., and also in the repeated attempts which have been made to improve recognized evils by means of Federal and State laws. In all this discussion one thing was felt to be more and more needed. Although there are many thoroughly trained men in the United States who are engaged in railway matters, men educated in both practice and theory, a deep knowledge of the inner meaning of railway affairs is lacking among the people and in the legislative bodies. Even the great railway systems and their heads manage chiefly according to their own experience and according to custom, not according to general fundamental principles. Moreover, there has been lack of an exact knowledge of the railways of other countries, and therefore of the possibility of making comparisons and conclusions from foreign experience to aid in handling the home railways. These needs were considered at a meeting of railway presidents in the spring of 1910. To meet them it was decided to create a new organization, which should have for its object the investigation of the economic situation of the railroads of the United States and of other countries and should make the results of its investigations broadly accessible. For this purpose a bureau was established under the name 'The Bureau of Railway Economics,' which was opened on the first of August, 1910, and can thus look back now on an activity of more than two years. The presidents of six of the largest railway systems are members of the committee and the managing director is Logan G. McPherson, a specialist in railway affairs, and extremely well trained in both practical and theoretical lines. At the head of the statistical department is Frank Haigh Dixon, a specialist also well known through numerous works, statistical and otherwise, and Richard H. Johnston, recently of the Library of Congress, is librarian. The bureau is situated in Washington. Its duty has been to keep in close touch with the Interstate Commerce Commission, and also to work over the publications of that Commission and make the results clear to the widest circles.

The bureau began its work immediately after opening. It publishes monthly statistics of American railways based on the monthly reports filed by the railways with the Interstate Commerce Commission, and has published a number of monographs, some of them most valuable. In some of these, strictly American conditions are treated, and in others comparisons between American and other railways are drawn from a strictly scientific point of view. The newest and most comprehensive publication is the one named at the head of this article, a catalogue of the literature on the economic side of railway affairs. It contains a systematically arranged collection of titles of the contents of 14 American libraries, among them 9 university libraries, the Library of Congress, the library of the Interstate Commerce Commission, and that of the bureau itself. With each entry there is a notation showing in which libraries the book is to be found.

The arrangement of the catalogue is as follows: In the first division (to page 140) are general works on the development and history of railways, biographies of individuals, and then works on the various departments of railway science (railways and the state, administration, operation, and traffic). The second division has to do with the railways of the respective countries, among which those of the United States and of the other American countries fill the largest space (pp. 141-348); then follow Europe (pp. 349-400), Africa, Asia, and Australia. In a special division (pp. 412-424) are collected periodicals and official proceedings and at the end is an alphabetically arranged list of names, which makes the use of the catalogue most convenient.

An inspection of the work shows how rich the collections of the United States are in railway literature, and not only in that of the railways of the United States, which appears to be fully represented, but also in

* Translated from *Archiv für Eisenbahnwesen*, November 1912.

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that of other countries. A large number of older works, rare even among us, on the history of the English, German, French, and other railways, are to be had in American libraries. On the other hand, I miss almost entirely the literature of the international railway freight law, and the commentaries of Gerstner, Rosenthal, Blume, and others are not mentioned. Only the bulletin of the central office at Bern is to be found. The name of Eger, a man of remarkable production in various fields, is missing.[1] It is just the railway freight law, and especially the international freight law of middle Europe, that should be of particular interest for railway specialists and teachers of political economy in the United States. Further, the libraries do not have that very valuable history of the railroads of the Austro-Hungarian monarchy, together with the two continuation volumes.[2] These are omissions which struck me as I examined the book and which do not at all lessen its value. But perhaps the Bureau of Railway Economics will take occasion to examine the catalogue of the Library of the Prussian Ministry of Public Works and thereby enlarge the contents of its own collection so far as its means allow. The make-up is excellent, the print clear and plain.

A. VON DER LEYEN.

ESSENTIALS OF ELECTRICITY. By W. H. Timbie. John Wiley & Sons, New York. P. 262. Index. For sale by the *Mining and Scientific Press*, San Francisco. Price $1.25.

This is one of the Wiley technical series for vocational and industrial schools, and is intended for use by wiremen and the electrical trades in general. Mr. Timbie is an experienced teacher and has prepared the text with an eye to its use for home study as well as with the aid of a trained instructor. The subjects include, in addition to the usual fundamentals, chapters on wire and wiring systems, generators and motors, method of locating and correcting trouble, batteries, and wiring diagrams.

ELEMENTS OF WESTERN WATER LAW. By A. E. Chandler. Technical Publishing Co., San Francisco. P. 150; index. For sale by the *Mining and Scientific Press*, San Francisco. Price $2.

The attention that is being paid to the water question by the Federal Government, as well as by the various state governments, makes the publication of Mr. Chandler's work especially pertinent at this time. As the question of water rights is a matter of law rather than engineering, the text is necessarily confined to the laws of the various states embraced within what is known as the West, and also includes the interpretation of these laws as exemplified by the various decisions of the courts. Mr. Chandler is especially able in expounding the stilted legal text, and his wide experience as a teacher has enabled him to clear away much of the fog that ordinarily clouds the mind of the layman when trying to translate legal phraseology into understandable English. Engineers especially will appreciate the value of this book, as there are few, if any of them, actively engaged in the practice of their profession who do not deal more or less with the question of water rights.

EXPLOSIVES. By H. Brunswig. Translated and annotated by L. E. Monroe and A. L. Kibler. P. 350, ill. John Wiley & Sons, New York, 1912. For sale by the *Mining and Scientific Press*. Price $3 net.

This is an admirably condensed, non-mathematical, critical résumé of present knowledge of the theory of explosives, and is unusual in that the author not only states that all the material has been compiled from easily available literature, but intimates that considerations of private employment have induced him to refrain from critical remarks where a contradiction exists between the literature and his own knowledge of the facts. The advance of physical chemistry has been so rapid that few have been able to keep conversant with the fundamental changes it has made in the concepts of technology. All those who have to do with the use or manufacture of explosives will be correspondingly grateful to Dr. Brunswig for gathering together the facts in regard to explosives and arranging them in accord with modern physical chemical views in so lucid a manner.

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[1]The preface to the catalogue specifically states that books on general railway law are not included.

[2]This history is listed on p. 352 of the catalogue, under the name of the association publishing it.

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Engineers' Note Book

Earthwork Excavation

As an aid to the correct estimation of the cost of moving earth by means of carts and scrapers, Halbert Powers Gillette, in his work on 'Earthwork and its Cost,' gives the following résumé of the opinions of various authorities on the behavior of earthwork upon loosening and upon subsequent consolidation. Morris's conclusions are as follows:

	Excavation, cu. yd...	Embankment, cu. yd.	Shrinkage, % .....
Yellow clayey soil...	6,970	6,262	10.15
Yellow clayey soil...	25,975	23,571	9.25
Light sandy soil....	10,701	9,317	12.93
Total	43,646	39,150	10.30
Gravelly earth (small-scale experiment)			12.00

George J. Specht gives his opinions as follows:

9398 cu. yd. in cut (heavy adobe clay) make 9470 cu. yd. fill, measured three weeks after finishing.

10,000 cu. yd. in cut (adobe in sandy loam) made 10,290 cu. yd. in fill.

29,000 cu. yd. in cut (adobe in sandy loam) made 30,330 cu. yd. in fill.

53,350 cu. yd. in cut (sandy loam with small amounts of adobe and hardpan) made 58,350 cu. yd. in fill, or about 9.4% increase.

202,634 cu. yd. in cut made 208,915 cu. yd. in fill (three months' work).

A series of tests made on the Taheand dam, the material being 62% earth and 38% gravel, resulted as follows:

Material in its natural banks weighed 116.5 lb. per cubic foot.

Material sprinkled and rolled (6-in. layers) in embankment, 133.0 lb. per cubic foot.

Material delivered by wagons, moist and dumped loosely, 76.6 lb. per cubic foot.

Material dug out of dam embankment, loose and shaken, 80 lb. per cubic foot.

The natural soil contained 19% of moisture, and 33% of water had to be added to it to fill all voids, making a total of 52% voids in the natural soil when loosened.

The following data were obtained from the construction of the Forbes Hill reservoir, Massachusetts:

	Cu. yd.
Hardpan measured before loosening..	17,466
Rolled hardpan embankment.....	15,474
Shrinkage, 11.4%, or.....	1,992
Material excavated as above.....	17,466
Estimated equivalent amount of stone (boulders, etc.) removed, 5.9%, or..	1,043

Thermal Efficiency Equivalents

By J. W. WHITE *

The use of the chart shown on the page opposite may be illustrated by the example following: Given an internal-combustion engine, whose builders guarantee the delivery of 1 hp-hr. on 0.44 lb. of 24-gravity oil. On scale A, opposite 0.44, we read the thermal efficiency as 31.25%. On scale B we find that this guarantee is equivalent to 1.53 kw-hr. per pound of fuel, allowing 10% for generator losses; also that it is equivalent to 2.28 hp-hr. per pound of oil. On scale C we find this guarantee equivalent to 12.45 kw-hr. per gallon of oil, allowing 10% for generator losses, and also that it is equivalent to 18.15 hp-hr. On scale D we find the economy guarantee is equal to 8150 B.t.u. per horse-power-hour. On scale E the equivalent readings are 512 kw-hr. per barrel of oil, including 10% for generator losses, or an equivalent of 762.5 hp-hr. Multiplying figures given on scales C and E by the constant for 24-gravity oil—that is, 0.951—we obtain a revised equivalent of 11.86 kw-hr. and 17.25 hp-hr. for scale C; and on scale E, 487 kw-hr. and 724 hp-hr., respectively. Inasmuch as these equivalents are figured on the basis of 16-gravity oil, which weighs 8 lb. per gallon, scales C and E should be corrected as above for any gravity oil by the correction factor for whatever gravity used. Scales B and D are not affected by these constants, as they are calculated on a weight basis only.

*Chief Engineer, Vix Engineering Co., Mills Bdg., San Francisco, Cal.

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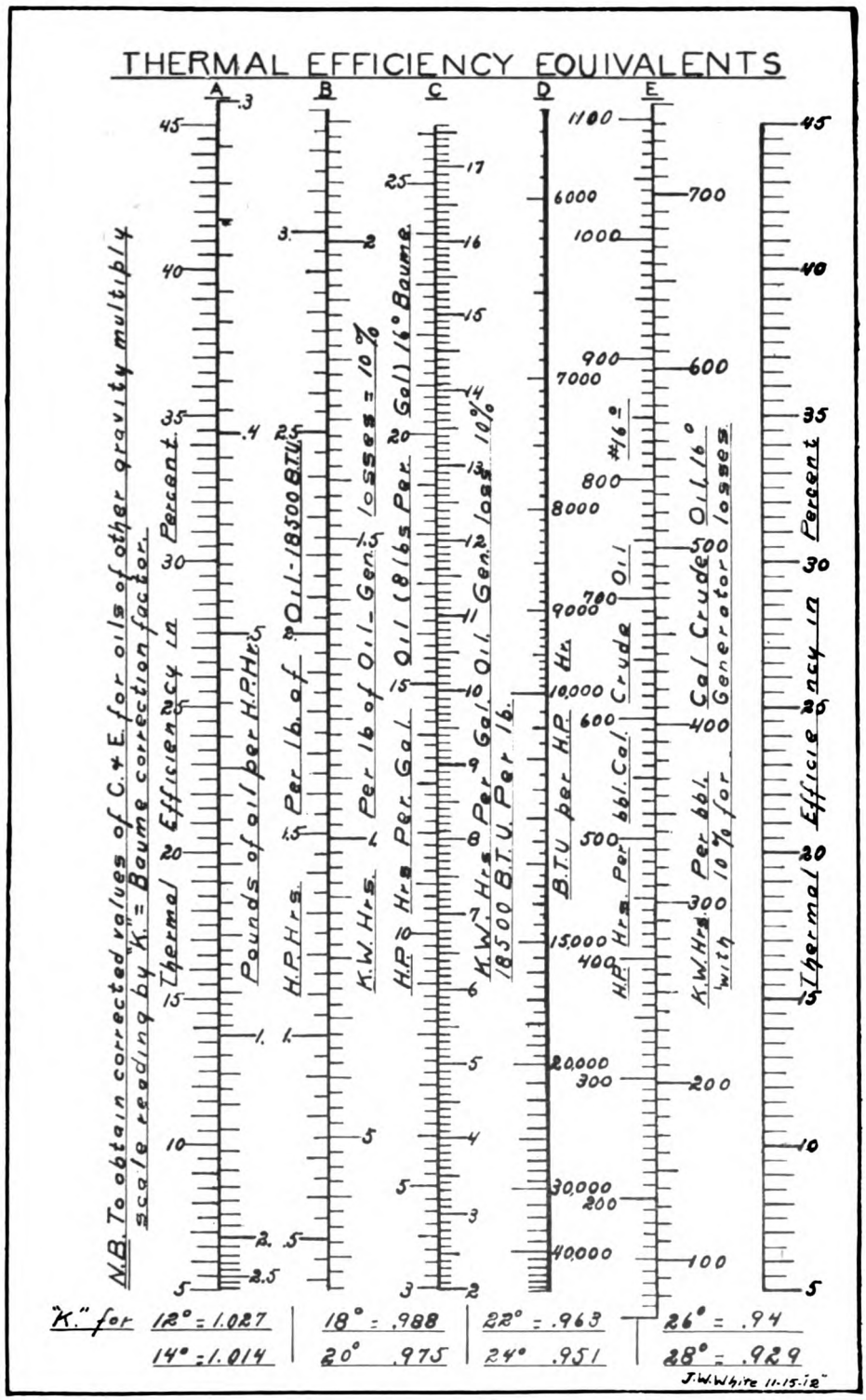

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Company Reports

J. G. White & Co., Inc., of New York, who for the past four years has maintained an office in San Francisco, announce the consummation of their plan to organize their engineering, construction, and managing departments into separate corporations. Henry A. Lardner, who has been manager of the San Francisco office of the company, becomes a vice-president of the engineering corporation, but will continue his residence here in charge of the Pacific Coast affairs; and Charles F. Conn, who has for some years been associated with the New York and San Francisco offices, will also remain here. The officers are: J. G. White, chairman finance committee; Gano Dunn, president; E. G. Williams, vice-president; A. S. Crane, vice-president; H. A. Lardner, vice-president; H. S. Collette, secretary; R. B. Marchant, treasurer. During the year ended October 1, 1912, the engineering and construction departments, now the engineering corporation, were retained on contracts totaling in cost over $28,000,000, and on appraisals and reports upon properties aggregating in value over $400,000,000. These services included practically all the many branches of engineering, and the company's clients were distributed throughout thirty states and the Dominion of Canada. The scope of the company's work is indicated by the fact that it included the complete rehabilitation of several public-service properties, and a number of hydro-electric developments of large capacity, as well as the designs for the drainage of 118,000 acres of farm lands in Florida. Among the prominent California projects with which J. G. White & Co. has been identified are the construction of the Oakland & Antioch Railway and its associate, the Oakland, Antioch & Eastern Railway, now building between Oakland and Sacramento, a distance of 84 miles; the construction of a natural-gas pipe-line 124 miles long and 12 inches diameter for the Midway Gas Co., which line is noteworthy because of its length and because it is to operate at a pressure of 450 lb. per square inch, the highest yet employed; the design and construction of storage-reservoir and power plants, both hydraulic and steam, for the San Joaquin Light & Power Corporation. Hydro-electric developments with which this company has been identified in other sections of the country include those on Big Sandy river, in Oregon; the Deerfield, an important tributary of the Connecticut river; the Savannah, near Augusta, Georgia; the Broad, near Columbia, South Carolina; the Ocoee, in the mountains of eastern Tennessee; and the St. Lawrence, near Montreal, Canada. The J. G. White Management Corporation announces as officers J. H. Pardee, president; F. H. Reed, vice-president; S. L. Selden, vice-president; T. W. Moffatt, secretary and treasurer. The business of the management company was established some years ago as a department to supervise the operation of properties in which J. G. White & Co., Inc., was interested. This department, which has now been incorporated into a separate company, was on December 31, 1912, acting as operating or consulting manager of public utility and railroad properties in the United States, Nicaragua, and the Philippine Islands, including the Helena Light & Railway Co., the Eastern Pennsylvania Railways Co. and subsidiaries, the United Light & Railways Co. and subsidiaries, the Associated Gas & Electric Co. and subsidiaries, the Augusta-Aiken Railway & Electric Corporation and subsidiaries, Kentucky Public Service Co. and subsidiaries, Pacific Railroad of Nicaragua, the Manila Electric Railroad & Lighting Corporation and subsidiaries, and other properties.

The Stone & Webster Engineering Corporation, incorporated under the laws of Massachusetts, has filed with the Massachusetts Secretary of State a statement of its financial condition, dated November 30, 1912, which is as follows:

Assets:	1912.
Real estate	$ 481,240
Machinery	12,292
Cash, and debts receivable	475,302
Securities	581,608
Total	$1,550,442
Liabilities:	
Capital stock	$ 500,000
Accounts payable	374,614
Mortgage indebtedness	250,000
Floating debt	300,000
Profit and loss	109,822
Reserve for depreciation	16,005
Total	$1,550,442

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Hints on Practice

Gas-Engine Troubles

If the engine fires irregularly, it may be due to any of the following causes: Insulation broken on wires, causing a short-circuit in the electric current. The contact at the timer may be poor, or the terminals on the coil may be loose or corroded. The spark-plug may be cracked, or the points not properly adjusted; they should be about 3/32 in. apart. In case of a weak battery, they may be closed a trifle. The fuel supply may not be regulated correctly; it might be so rich it will not ignite, or so weak it cannot be ignited. In either case the engine would run irregularly. The spark coil may be poorly adjusted, or the platinum points pitted and stick. Sometimes an engine will fire regularly but have little power. This may be on account of poor compression, which is due to worn or broken rings, broken or warped valves, leaky gaskets, scored or worn cylinder walls, and weak valve-springs. The fuel mixture may be weak or lubrication poor. The muffler may be stopped with a sooty deposit until the back pressure will destroy the power. The exhaust valve may be lifted only part way, not allowing the burned charge to be expelled from the cylinder. A hissing sound can be caused by a broken spark-plug allowing the compression to be forced through the fracture, or by the compression blowing past the rings. A cracked exhaust-pipe, or an open compression-cock will emit a hissing sound, as will a blown gasket between the exhaust pipe and the muffler. In case the engine cannot be started, something may be broken, but, if such is not the case, the trouble will likely be found in some of the following: Cylinders dry for want of oil; foul or broken spark-plug; poor compression as described in irregular firing; the batteries may be exhausted or some of the connections broken; the switch may be broken or not turned on. Water in cylinder caused by a leak in the water-jacket will prevent the engine from starting. The inlet valve, if not mechanically operated, will many times stick and prevent the engine taking a charge of fuel. An excessive amount of lubrication in the cylinder makes starting difficult, especially in cold weather. If the engine runs well and stops suddenly, the cause may be that the spark-plug is broken or blown.

A loose terminal may be the cause, tremble spring on spark-coil stuck, trouble at contact points of timing device, gears jammed or broken, valves stuck or broken. In case the engine runs but seems to have no power, look for the following: Over-rich mixture, caused by too much gas and not enough air; weak mixture, caused by too much air and not enough gasoline; loose or slipping fly-wheel, insufficient lubrication, valves in bad condition, worn or broken rings, weak batteries. If the engine has been running well and gradually slows up, missing explosions, look for trouble in the fuel supply, or fouled spark-plugs, insufficient lubrication, weak batteries, wiring defective, being nearly broken and hanging by a thread, or loss of compression. Explosions in the muffler are due to any of the following: Exhaust valve stuck, weak mixture failing to burn in the cylinder and burning in the muffler, weak spark not firing the charge until the working stroke is nearly finished. In this case it will not burn while passing to the muffler. The water getting too hot, causing overheating, is generally caused by some of the following: Clogged pipes, incorrect timing of the valve, fan not working, pump broken or disconnected, oil in the water, muffler stopped up, and a very late spark. In case there are explosions in the mixing-valve, look to the intake valve or its spring. The valve may be broken or leaking, or the spring may be weak, not seating the valve properly, or the mixture may be weak, late spark, or the valves incorrectly timed. When the engine begins to knock, it should be stopped at once and some of the following examined: Fy-wheel may be loose on the shaft, or the cylinder may be loose, rings may be broken or badly worn, bearings may be loose and need tightening, carbon deposit on the cylinder head, spark occurring too early, over-rich mixture, loose crosshead bearing, and defective lubrication; this will cause knocking when the piston is about to sieze.—*Gas Power.*

A LARGE watt-hour meter to be installed for the Hydraulic Power Co., Niagara Falls, will be capable of measuring 60,000 amperes at 650 volts, equal to about 50,000 hp. The meter, which is of the mercury type, is being constructed by the Sangamo Electric Co., Springfield, Illinois.

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Engineering News

Railways

San Francisco.—Surveys are being made for a new street-car line to be built on the extension of Sunnyside avenue connecting Sloat boulevard and Corbet avenue. J. B. Zimdars, chairman of the Sunnyside Improvement Association, is interested in the project.——The Idaho Northern Railway Co., Ltd., has been transferred to the Oregon Short Line; the price paid for the property is said to have been about $1,000,000. The line at present in operation lies between Nampa and Murphy, Idaho, a distance of 29½ miles. Extensions are planned which will make a total of 144 miles of track when completed.——Plans and specifications have been prepared by the city engineer for the extension of the municipal railway from its present Geary-street terminus along Market to Sutter and Sansome, where a connection is to be made with the outer tracks to the ferry. Cost of construction is estimated at $27,000.——The Southern Pacific Company has ordered additional equipment, amounting in all to about $6,000,000, including 4000 freight cars, 50 locomotives, and 100 steel passenger cars.

Santa Barbara.—Work has commenced on the reconstruction of the Santa Barbara street railway line; $250,000 is to be spent upon this work, and $250,000 is being held for future extensions and improvements.

Los Angeles.—The Los Angeles Railway Co. will add 75 new cars to its equipment during the coming year.——The Los Angeles, San Pedro & Salt Lake Railway will commence relaying its entire right-of-way, a distance of 789 miles, with 90-lb. rails. The total amount involved aggregates $5,500,000. The initial expenditure will be $250,000 for the first 36 miles out of Los Angeles.——Report has been filed by Franklin D. Howell, consulting engineer, with relation to the municipal street railway. Plans and specifications are in course of preparation.——The Pacific Electric Railway will expend about $1,000,000 on South Pasadena Short Line construction, and an extension is to be built from the southern limits of Riverside to Corona at a cost of $350,000.——The Board of Public Works has awarded a contract to the Pacific Electric Railway for the construction of the San Pedro link of the municipal railway at a price of $246,575.——The Salt Lake railway is considering the construction of a line from Los Angeles to San Diego, a distance of 130 miles. Estimates of cost of construction vary between $7,000,000 and $10,000,000.

San Bernardino.—Santa Fé Railway is expending $2,000,000 for the construction of a second track and a tunnel at Cajon pass. A pre-cooling plant is also under construction at a cost of $250,000.——The Pacific Electric Railway Co. is putting in an extension between San Bernadino and Riverside, via Colton.

Hollister.—Surveys have been completed for the extension of the San Juan Pacific Railway from San Juan to this city, and construction work is to be rushed to completion. E. U. Leh is chief engineer.

Sacramento. — Deed and mortgage have been filed with the county recorder showing the transfer of property at Third and I streets to the Oakland, Antioch & Eastern Railway. This property is to be used for a terminal.

Oakland.—The tunnel of the Oakland, Antioch & Eastern Railway through Redwood peak has been completed. This tunnel is 3400 ft. long and 30 days will be required for completion of the necessary timbering.

Grants Pass, Oregon.—Estimates of the cost for the first unit of the Pacific Interior Railway, which will be 15 miles long, have been completed. The figures are $290,115.32.

Portland, Oregon.—The Washington Electric Railway Co. will undertake new construction this year aggregating a cost of $2,000,000. A 12,000-hp. hydro-electric plant will be constructed on the Kalama river, and railroad units will be constructed between Orchard, Washington, and Vancouver, Washington, between the southern terminus of the line operating out of Chehalis, Washington, and the Cowlitz river between Centralia, and Olympia, Washington.

Caldwell, Idaho.—It has been stated that work on the Winnemucca Northern Railway will recommence in the spring. The projected route is to connect Winnemucca, Nevada, and Caldwell, Idaho, a distance of 120 miles.

Spokane, Washington.—A contract has been awarded by the Canadian Pacific Railway Co. to Janse Brothers, Boomer & Hughes, of this city, for the construction of 375 miles of railroad in western Canada.——According to John D. Ryan, president of the

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Great Falls Power Co. and the Amalgamated Copper Co., the power available in the Rocky and Cascade mountains is sufficient to electrify 10,000 miles of railroad. Work has been commenced at Great Falls on two additional dams which will cost approximately $4,000,000.

Power, Gas, and Electricity

San Francisco.—Plans of the International Power & Manufacturing Co. of the state of Washington are being held up through the action of the Interior Department in withholding the application of the company for patents on lands. It is proposed to undertake the development of a series of power projects that will produce an aggregate of 200,000 hp.——The Los Angeles Gas & Electric Corporation has applied to the Railroad Commission for permission to construct and operate upon the public highways a pipe-line for the distribution of artificial and natural gas in Los Angeles county.——The Railroad Commission has issued an order permitting the Southern Counties Gas Co. to issue additional bonds to the amount of $19,500.——A. A. Weber has applied to the Railroad Commission for permission to operate a gas plant in Dinuba, Tulare county.——The Oro Electric Corporation has applied for permission to serve Stockton with electric current for light and power.——The Railroad Commission has granted authority to the Imperial Valley Gas Co. to issue bonds in the sum of $154,500 for the purpose of extending its system to cities in the Imperial valley.——The Commission has granted the application of the Western States Gas & Electric Co. to issue bonds in the amount of $397,000.——The Southern Sierra Power Co., Inyo county, has commenced operations. The generating station has a present capacity of 87,000 hp.——J. G. White engineering corporation, will design and install a hydro-electric plant of 5000-hp. capacity for the San Joaquin Light & Power Co. on the Tule river.——The Elsinore Electric Light & Power Co. has applied to the Railroad Commission for permission to sell its property in Riverside county to the Southern Sierra Power Company.

Live Oak, Sutter County.—A new lighting system is to be installed by the city.

Redlands.—The Southwest Electric Co. will install a system of ornamental electroliers at a cost of $10,000.

Los Angeles.—The Pacific Electric Co. has asked permission of the Railroad Commission to issue bonds aggregating $7,034,000 to provide funds for improvements as follows:

Covina-San Dimas line	$ 53,000
Riverside-Colton-San Bernardino line	408,000
Glendale-Burbank line	53,000
Lankershim extension	236,000
Magnolia avenue line	76,000
Pasadena city lines	97,000
San Bernardino extension	1,424,000
Dominguez town-site line	46,000
San Pedro-Hermosillo line	42,000
Torrance line	42,000
Van Nuys extension	42,000
Van Nuys-San Fernando line	213,000
Van Nuys-Owensmouth	215,000
Watts homeward line	108,000
Santa Ana-Orange line	64,000
South Pasadena cut-off	159,000
Tunnels, bridges, etc.	444,000
Stations, shops, etc.	156,000
Redlands-San Bernardino line	43,000
San Bernardino Highlands line	105,000
Alamitos bay city line	24,000
Covina line	34,000
Gardena-Strawberry Park line	17,000
Hawthorne-El Segundo line	161,000
Pasadena local lines	40,000
Santa Ana line	76,000
Upland-San Antonio line	25,000
Del Rey-Redondo line	87,000
Hermosa Beach line	175,000
Redondo Beach	175,000
Whittier-La Habra line	105,000

In addition the application enumerates improvements throughout the entire Pacific electric system which the company proposes to make from the proceeds of the bonds.——The local power companies, acting jointly, have offered approximately $750,000 to the city for power to be generated by the Los Angeles aqueduct. The offer calls for a price of 0.65c. per kilowatt-hour, the peak-load to be 35,000 hp., and the ordinary load 17,000 hp. This would give the city an annual revenue from this source of approximately $750,000.

Caldwell, Idaho.—The Beaver River Power Co. has completed setting the high-tension power-line poles from Boise to Caldwell, Idaho.

North Yakima, Washington.—The Pacific Power & Light Co. has undertaken the im-

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provement of the Wapatox ditch at an expenditure of $500,000. Eight miles of this ditch is to be lined with concrete. D. F. McGee, of Portland, is chief engineer in charge of the work at North Yakima.

Irrigation and Water Supply

San Francisco.—The Railroad Commission has granted the application of the California-Michigan Land & Water Co. to serve water upon the Cribb-Brodek tract in Los Angeles county. —— Permission has been granted to the Peoples Water Co. to issue promissory notes to the amount of $500,000, to be secured by the company's 5%, 30-year gold bonds in the aggregate of $1,500,000. ——A. J. Rich & Co., real estate dealers of San Francisco, have undertaken the promotion of an irrigation project embracing about 90,000 acres of land in southern Solano county, below the 50-ft. contour line with 15 miles of frontage on the Sacramento river. Ford, Bacon & Davis, of New York, and L. W. Symmes and Thomas Means have been in charge of the engineering work in connection with this project.——The Railroad Commission has granted permission to the Palmdale Water Co. to purchase for $55,000 the entire water system of the South Antelope Valley Irrigation Co., in Antelope, Los Angeles county.

Sacramento.—Articles of incorporation for the Yuba Land Co. have been filed. The capital stock is $1,000,000. The directors are J. M. Henderson, H. E. Yardley, and D. W. Carmichael, of Sacramento; E. R. Dudley, of Oakland; B. B. Dudley and P. M. Baier, of Visalia; W. F. Cordes and C. W. Durbrow, of San Francisco, and E. Richardson, of Berkeley.

Natoma.—The Alder creek pumping station for the Natomas Consolidated of California has commenced operation. Thirty thousand acres will be placed under irrigation.

Alturas, Modoc County.—Leland & Meyers are said to have invested approximately $600,000 in land improvements in Modoc county during 1912, and the improvements contemplated for 1913 will bring their total investment up to $1,000,000 in this district.

Los Angeles.—Representatives of the Pacific Coast Fire Underwriters Association have approved the plan for salt-water fire protection about to be installed at Long Beach. Ten-year bonds will be issued to provide funds. A high-pressure pumping plant is to be built for delivering water at a hydrant pressure of 150 lb. minimum. Twelve-inch mains will be laid with 8 and 10-in. branches. The initial pumping plant will include three units, each with a capacity of 1000 gal. per minute against a pressure of 150 lb. The pumps will be gasoline-engine driven.——Application has been made to the State Railroad Commission by the Torrance Water Power & Light Co. for authority to issue $200,000 in stocks and bonds against the water system now being installed. The water-supply system includes 12 miles of 33-in. pipe, 5 miles of 20-in. pipe, 40,000 ft. of 8-in. pipe, 30,000 ft. of 10-in. pipe, and 60,000 ft. of mains from 4 in. to 16 in. ——The city council has decided to transfer $300,000 in installments of $50,000 each from the reserve fund to the water bond fund for aqueduct construction.

Redlands.—The city trustees have let contracts for approximately $55,000 worth of material for use in the construction of a municipal water system. The United States Cast Iron Pipe & Foundry Co. was given the contract for the cast-iron pipe, the Smith-Booth-Usher Co., of Los Angeles, the contract for the wrought-steel pipe, the Crane company the contract for the valves, and the Waterworks Supply Co., Los Angeles, the contract for the Corey hydrants.

Santa Ana.—The city trustees of Fullerton have let a contract for the construction of a municipal water-works system to C. D. Vincent, of San Francisco, for the sum of $44,405.33. One hundred and twenty-five days have been allowed for the completion of the work.

Rochester, Nevada.—A water-works plant is in contemplation. U. W. Harwood, W. Borland, and C. F. Campbell have the matter in hand.

Portland.—It is stated that the irrigation project of the Oregon Valley Land Co. for irrigating 60,000 acres in the Goose Lake valley will be completed in 1913.——The Berney Construction Co. is building a dam on Drews creek for Lake View, Oregon.—— Work is to be started on the Paisley project, 40 miles north of Lake View, Oregon, for the Portland Irrigation Company.

Helena, Montana.—H. N. Savage, supervising engineer for the U. S. Reclamation Service, has announced that work is to commence on the Sun river project immediately. The work involves construction of a canal

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45 miles long, and two tunnels, one 1000 ft. and the other 2200 ft. long. The ultimate capacity of the canal will be 2000 sec-ft. The tunnels will be 12-ft. diam. and will be concrete lined. The diverting dam at Sun River canyon will be 145 ft. high; pipe-lines crossing Sun river will be 9-ft. diam. The construction work will be conducted by the U. S. Government forces and by contract aggregating $1,500,000. Work on the construction camp at Sun river, 70 miles from Great Falls, has been practically completed and will provide accommodations for 250 men.

Walla Walla, Washington. — Extensions above the head works of the water system from the intake to the Forest Reserve boundary are being contemplated by the city officials. Ray Fulcher is the engineer making the report.

North Yakima, Washington.—The Northern Pacific Railroad is making surveys in Kittitas, Yakima, and Benton counties for an irrigation project covering 2000 acres in the Yakima valley. W. R. King, of Portland, Oregon, has been the engineer in charge of the work.——The Pacific Power & Light Co. has offered to sell the water system owned by it at North Yakima to the city at a valuation to be fixed by a board of appraisers.

Ellensburg, Washington.—The Secretary of the Interior has approved a contract with the Kittitas reclamation district of Washington for furnishing water stored in Kachess and Keechelus lakes by the Government upon the basis of a payment of $882,000, with a readjustment of cost in case the total cost of storage shall be ascertained to require a greater payment by the district on the basis of an acre-foot storage to be delivered under the contract. This price is on the basis of $12.60 per acre.

Miscellaneous Engineering Construction

San Francisco.—Board of Public Works has recommended the construction of a sewer system in the district between Ocean View and Ingleside, the cost of construction to be paid out of the surplus funds on hand from the sale of sewer bonds of 1904. ——Plans and specifications for the construction of an out-fall sewer on San Jose avenue between Lake View avenue and Ottawa street are in course of preparation.——A crew of men in charge of D. A. Riedy, assistant city engineer, has practically completed the boring of test-holes along the route of Twin Peaks tunnel.——Contract has been let for San Francisco pier No. 37 to the Thompson Bridge Co.; price $475,200. The pier will be 1080 ft. long, 200 ft. wide, with reinforced concrete pillars on timber piling.——The Harbor Board has approved plans and specifications submitted by Carl Uhlig, assistant harbor engineer, for pier No. 41.

Oakland.—The following were the bids received for the construction of a reinforced-concrete bridge over the stream which connects Lake Merritt with the estuary at Eighth street: W. N. Concannon, $30,000; F. Rolandt, $29,631.40; Healy-Tibbetts Co., $30,750; State Construction Co., $33,615; A. W. Gorrill, $33,748; Portland Concrete Pile Co., $28,485.50; Foster-Vogt Co., $29,897; Contra Costa Construction Co., $27,490; Coast Improvement Co., $27,500; Ernest A. Sonberg, $28,434; Ross Construction Co., $25,714; Monson Brothers, $27,550.——Plans and specifications for the improvements of Fourteenth street between Wood street and a point 500 ft. westerly have been adopted by the city council. W. J. Baccus is commissioner of streets.——The San Francisco, Oakland & San Jose Terminal Railways has awarded a contract to Twohey Brothers for filling in the Key Route pier at a cost of about $2,000,000.

Sacramento.—The California flood control committee, consisting of A. L. Shinn, A. E. Anderson, and V. S. McClatchy, has suggested that the scheme for flood control as recommended by the California Débris Commission, calling for the expenditure of $33,000,000, be divided into three elements, as follows: (1) The cost of construction of the river levee and levees for the by-passes to be sustained by the owners of reclamation lands and reclamation districts for which these levees form necessary protection. (2) The expense involved in securing rights-of-way for by-passes, and the cost of securing lands for enlarged river channels and for keeping such channels clear of brush. This expense should be borne by all the lands benefited in proportion to benefits derived. This would involve perhaps the creation of a district including all lands below the flood plane. (3) The work of widening the mouth of the river and of dredging and rectifying the river channel to the head of

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navigation and of constructing weirs and smaller works. These elements to be paid for jointly by the state and the nation under the plan now being followed in the work at the mouth of the river.

Berkeley.—The city council is considering three alternative schemes for sewer improvements, the first to cost $475,000, the second $170,000, and the third $60,000. The first plan provides for the construction of sewers for practically every section of the city, the second provides for the construction only of an outfall system, and the third provides for improvements of present conditions along the waterfront only. J. J. Jessup is city engineer.

Chico.—Mery Brothers have completed the new steel truss bridge over Little Chico creek; the contract price was $1390.

Reno.—According to a report recently filed by J. R. Meskimons, city engineer, $75,000 has been expended for municipal improvements during the year 1912, including the construction of a rock-crushing plant, street pavement, repair outfit, concrete culverts, board walks, sewer extensions and repairs, and much street work was done.

Pasco, Washington.—A bill is to be introduced in the state legislature authorizing the appropriation of $250,000 for the construction of a bridge between Pasco and Kennewick.

Kellogg, Idaho.—Survey has been commenced for the construction of a trunk sewer.

Spokane, Washington.—A summary of the money expended for municipal improvements during the year 1912 is as follows:

Street and sewer work	$ 992,000
Water mains	75,000
New reservoir	90,000
Hangman creek bridge for 1912	200,000
New city hall, 1912 portion	200,000
New buildings, city yards	10,000
New buildings, fire department	8,000
Total	$1,575,000

Riverside, Cal.—Bonds for $1,160,000 were voted January 14, $342,000 of which will be used for consolidating the three privately owned plants that were purchased from the proceeds of the bond issue. This work will require new reservoirs, pumping machinery, and a complete reconstruction of the three plants, which will be taken over by the municipality.——Plans and an efficiency report have been completed on municipal lighting plant at Riverside. Plans call for an expenditure of $429,112 on hydro-electric plant, $100,351 steam reserve plant, or an alternate oil-engine plant of 2000 kw. capacity, $200,000.

Billings, Montana.—Plans have been completed and submitted to the city for water works improvements, including filtration, steel tower and tank, settling basins, estimated cost $25,000. Election will be called to vote bonds for this improvement.

Livingston, Montana.—Plans are being prepared for a complete new water-works plant, including filtration and settling-basins. Election will be called as soon as plans are completed, which will be in about 30 days.

Los Angeles.—Board of Works has let a contract to Holt & Jeffry for the construction of the Arroyo de la Brea storm sewer for the sum of $534,844.34, the city engineer's estimate being $540,000. One year is allowed for the completion of the work.——The Board of Harbor Commissioners has instructed the city engineer to prepare estimates for the cost of grading First street, San Pedro, to either 5 or 7% westerly to the First-street landing. The distance required will be from 400 to 600 ft.——The city engineer has reported that the Wilmington & San Pedro road, with the exception of two small stretches, is practically completed.——The filling of area B in the outer harbor is completed to a point 1000 ft. beyond the end of the dock site.——The California Highway Commission and the State Board of Control are investigating the possibility of purchasing the Monolith plant, with a view to utilizing it for furnishing cement for building state highways under the $18,000,000 bond issue. The Los Angeles city council has fixed a price of $550,000 minimum for the sale of this plant.——The people of Los Angeles are to vote on February 11 for bond issues as follows: Surplus water distribution, $6,000,000; electric-power distribution, $6,500,000; harbor improvements, $2,500,000; municipal railroad, $1,000,000; Normal School site, $600,000.——Summary of expenditures, Los Angeles harbor improvement: A statement of appropriations and expenditures on San Pedro harbor improvement has been compiled and presented to the city council. Out of $1,000,000 appropriated for the inner harbor, an available balance remains of $445,531.44, while of $2,000,000 appropriated for the outer harbor, the available balance amounts to $532,612.77.

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INNER HARBOR

Total to be expended		$1,000,000.00
Expenditures to November 1:		
Dredging and filling at Wilmington	$265,511.55	
Improving J street	11,761.10	
Wilmington and San Pedro road	23,410.59	
Preliminary investigations	648.28	
Damages to property owners	25,621.60	
Mormon island channel wharf survey	100.00	
Storehouse	227.11	
Legal services	2,998.66	
Salary roll	11,619.42	
Equipment	1,291.67	
Administration	2,721.55	
Total		$345,911.53
Work for which contracts have been let:		
Completion J street improvements	$ 16,467.50	
Completion Wilmington San Pedro road	17,012.19	
Mormon island channel wharf	101,955.34	
Total		135,435.03
Work contemplated (estimated):		
Improvement Seventh street	$39,280.00	
Improvement Canal street	19,178.00	
Improvement Fries street	14,664.00	
Total		73,122.00
Available balance		445,531.44
		$1,000,000.00

OUTER HARBOR

Total to be expended		$2,000,000.00
Expenditures to November 1:		
First street landing	370.94	
Huntington concession	56,763.98	
Preliminary investigations	1,874.84	
Timm's Point judgment	351,886.48	
Other Timm's Point cases	142,781.70	
West jetty	2,050.02	
Nob Hill judgments	226,996.86	
Salary roll	16,626.84	
Equipment	2,490.70	
Legal services	6,169.69	
Administration	5,249.68	
Total		$ 813,261.73
Bills due but not paid:		
Huntington concession contracts	$184,515.52	
Moving west jetty	9,289.98	
Total		193,805.50
Estimated cost concrete wharf, Huntington area		460,320.00
Available balance		532,612.77
		$2,000,000.00

Streets and Roads

San Francisco.—Surveys for a scenic boulevard connecting the Panama-Pacific Exposition grounds with the Ocean boulevard at the Cliff House have been prepared for the city at the direction of the city engineer. Rights-of-way are in process of negotiation and bids will be advertised for within a short time.

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Watsonville.—A movement is under way toward bonding the county for $1,000,000 to provide funds for road-building to be completed before the opening of the Panama-Pacific Exposition.

Los Angeles.—The city council has adopted plans recommended by Franklin L. Howell, consulting engineer, for the construction of a 75-ft. boulevard from Fourth to Fourteenth streets, San Pedro.

El Centro.—The San Diego-Arizona auxiliary of the Southern Ocean-to-Ocean Highway Association has been organized at Yuma, Arizona. E. Fletcher of San Diego is president, C. H. Akers of Phoenix is vice-president, and W. B. Gross of San Diego is secretary.

Santa Monica.—The city is repaving Santa Monica boulevard for a distance of three miles.

Spokane, Washington.—City engineer has been requested by the Commissioner of Public Works to prepare plans for the improvement of Treat avenue.

Olympia, Washington.—According to the annual report just issued by W. J. Roberts, Commissioner of Highways, $82,036.49 was expended during the fiscal year ended September 30, 1912, for permanent highway construction. The maximum mileage of road-building for any one county is that recorded for Spokane, which is shown to have completed or had under way 7.07 miles of asphalt macadam, 1.46 miles of water bond macadam, and 16 miles of gravel roads. In King county the mileage is 1631, of which the greater part is 'Warrenite,' on either a crushed rock or concrete base.

Colfax, Washington.—The county commissioners, acting upon the recommendation of John M. McCaw, county engineer, have placed orders for permanent highways No. 4 and 5 with the Spokane Asphalt, Macadam & Paving Co., the price being $13,779 and $23,628.32, respectively. Section No. 4 calls for the construction of two miles of water-bound road, and section No. 5, 2.8 miles of oil-bound macadam road.

Petroleum

California oil dividends for December were as follows:

Amalgamated	$1.00	$50,000.00
American Pet., pfd	0.005	8,755.00
do common	0.00⅛	39,607.00
Caribou	0.01	8,070.00
Central	0.0075	7,500.00
Claremont	0.01	5,000.00
De Luxe	0.30	30,000.00
Home	0.01	5,000.00
Mount Diablo	0.015	7,500.00
New Pennsylvania	0.005	5,000.00
Paraffine	0.01	3,000.00
Record	0.01	5,000.00
Monte Cristo	0.02½	12,500.00
S. F. & McKittrick	0.01	5,000.00
Sauer Dough	0.0075	2,992.50
Section 25	0.50	20,000.00
State Consolidated	0.01	5,000.00
Traders	0.006	9,000.00
Union Oil	0.006	194,743.60
Union Provident	0.006	91,402.02
United Petroleum	0.006	48,450.60
W. K.	0.02	10,000.00
Western Union	0.005	5,000.00
West Coast, pfd	1.00	10,408.00
Total Calif. companies.		$488,928.12
Mex. Pet., Ltd., pfd	0.00⅔	80,000.00
Grand total		$568,928.12

Production statistics for California fields for December were as follows:

San Joaquin valley—	December. Total bbl.	Daily av.
Coalinga	1,574,205	50,777.58
Kern River	843,064	27,195.61
McKittrick-Belridge	547,164	17,650.45
Maricopa	385,488	12,435.09
Midway	2,236,567	72,147.32
Lost Hills	133,327	4,300.87
Total San Joaquin val.	5,719,815	
Coast region—		
Santa Maria, Lompoc, Cat Canyon	406,353	13,108.16
Summerland	4,350	140.32
Total coast region	410,703	
Southern fields—		
Olinda, Brea, Puente	509,916	16,448.90
Salt Lake-Sherman	216,542	6,985.22
Whittier	64,954	2,095.29
Coyotes-La Habra	169,278	5,465.06
Los Angeles City	31,842	1,026.79
Newhall	10,040	323.91
Ventura County	68,406	2,206.64
Total southern fields.	1,070,978	
Grand net total state.	7,201,496	232,418.06
Field fuel	421,798	13,606.39
Gross total	7,623,294	246,024.45

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Shipments	6,780,443	218,723.96	
Losses	158,651	5,114.74	
Total outgo	6,939,094	223,838.70	

Field development for December was as follows:

Coalinga—New rigs, 6; wells drilling, active 61, idle 60. Kern River—New rigs, 1; wells drilling, active 2, idle 4. McKittrick-Belridge—New rigs, 6; wells drilling active 16, idle 37. Maricopa—New rigs, 2; wells drilling, active 35, idle 59. Midway—New rigs, 19; wells drilling, active 106, idle 94. Lost Hills—New rigs, 4; wells drilling, active 19, idle 30. Santa Maria, Lompoc, Cat Canyon—New rigs, 1; wells drilling, active 17, idle 39. Olinda, Brea, and Puente—New rigs, none; wells drilling, active 25, idle 5. Salt Lake—New rigs, none; wells drilling, active 13, idle 2. Whittier—New rigs, none; wells drilling, active 8, idle 3. Coyotes-La Habra—New rigs, 1; wells drilling, active 29, idle 2. Newhall—New rigs, none; wells drilling, active 2, idle 3. Ventura County—New rigs, none; wells drilling, active 25, idle 28.

Wells abandoned—Coalinga, 2; Midway, 11; Santa Maria, 3; Coyotes-La Habra, 2.

Field conditions for December were as follows:

	Month's Complet'ns.		Producers.	
	No.	Outp.	Act.	Idle.
Coalinga	10	680	842	243
Kern River	9	91	1700	172
McKittrick-Belridge	8	510	295	31
Maricopa	2	85	267	133
Midway	27	4695	707	204
Lost Hills	5	550	51	1
*Santa Maria	1	100	267	20
Olinda-Brea-Puente		...	329	18
Salt Lake	2	100	291	13
Whittier		...	142	12
Coyotes-La Habra	4	2000	14	...
Los Angeles City		...	412	...
Summerland		...	125	25
Newhall		...	79	4
Ventura County	2	200	311	27
Totals	70	9011	5832	903

*Santa Maria, Lompoc, Cat Canyon.

Stocks on hand at the end of December were as follows:

	Field Stks.	Pipe-line.	Total.
Coalinga	377,778	2,482,372	2,860,150
Kern River	406,200	29,882,075	30,288,275
McKittrick	87,300	934,940	1,013,040
Maricopa	249,385	446,632	696,017
Midway	497,500	1,837,422	2,334,922
Lost Hills	15,700	234,022	249,722
Santa Maria	272,708	414,026	686,734
Fullerton	34,818	163,721	198,539
Salt Lake	136,312	51,882	188,194
Coyote	28,440	.....	28,440
Whittier	28,986	.....	28,986
Los Angeles	15,000	234,055	249,055
Newhall	3,850	.....	3,850
Ventura	17,072	65,027	82,099
Outside points	.....	8,635,169	8,635,169
Totals	2,171,049	45,381,343	47,552,392

Note—119,081 bbl. was added to December pipe-line stock on account of readjustment.

Summary of the California ouput for 1912 is as follows:

	Total prod.	Ship'ts.	Stocks.
January	7,149,701	6,398,846	*41,648,535
February	6,532,682	6,034,134	42,060,297
March	6,923,908	6,030,906	43,005,609
April	6,810,953	5,591,339	43,899,497
May	6,882,028	6,425,681	44,291,423
June	6,895,865	6,420,405	44,919,262
July	7,013,858	6,314,579	45,490,175
August	7,170,989	6,685,106	45,924,450
September	7,222,185	6,400,580	46,674,172
October	7,621,703	7,208,143	46,966,428
November	7,176,197	6,897,609	47,170,909
December	7,201,496	6,780,443	47,552,392
Total	84,601,565	77,187,771	

(*Stocks are figured with varying allowances for loss each month in addition to the shipments. The surplus given is merely the difference between commercial shipments and production. To December pipe-line stock, 119,081 bbl. was added on account of readjustments.)

Summary of the output of other fields within the United States is as follows:

	Total, 1912.	Total, 1911.
Pennsylvania	25,761,530	23,502,036
Lima	4,761,536	5,787,996
Illinois	24,659,536	28,188,552
Kentucky	475,545	468,312
Mid-Continent	51,791,105	55,440,050
Panhandle	3,620,000	1,573,504
Texas-Louisiana	9,996,734	12,655,753
Totals	121,065,500	127,626,203

Exports for December were as follows:

	Gallons.	Value.
Crude	2,945,000	$ 79,750
Illuminating	5,911,972	268,500

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Lubricating	120,663	31,743
Gasoline, etc.	146,181	22,194
Fuel oil	13,018,821	282,272
Asphalt	477	8,942

San Francisco.—The Associated Oil Co. has broken ground at Port Costa for the construction of a refinery, to cost approximately $1,000,000, for the production of gasoline, kerosene, stove and engine distillate, road oil, and fuel oil.——The oil refinery now in course of construction at Tulare for the American Union Oil & Refining Co. will be in operation about March 1.

Bakersfield.—The Independent Oil Producers' Agency will construct a fractionating plant near the western terminus of the Producers' transportation pipe-line, at a cost of $10,000.

Maricopa.—The Pacific Pipe-Line Co. has purchased 14 acres at Ventura for a pipeline terminal site, and is preparing to build its line from Maricopa to Ventura, a distance of about 80 miles.

Tampico, Mexico.—The Compania Mexicana de Petroleo El Aguila, S. A., will construct a crude-oil refinery in three units, three miles from Tampico on the Mexican National railroad, the first unit of which will be a topping plant which will have a daily capacity of about 12,000 bbl. of crude oil.

Panama-Pacific Exposition

A campaign is to be inaugurated by the Exposition management to obtain additional funds. A statement of resources and liabilities is as follows:

The State of California has taxed itself	$ 5,000,000
The city of San Francisco has bonded itself	5,000,000
Subscriptions totaling $6,100,000, which on a 90% collection basis will yield	5,500,000
Interest on bank balance and the premium on city bonds will be.	250,000
Total	$15,750,000
Liabilities:	
Preliminary period up to Sept. 30, 1911	$ 400,000
Administrative and executive, exhibits, exploitation, concessions, and admissions	2,000,000
Allowance for the purchase of real estate, rental of site, taxes, removal of buildings, etc.	1,250,000
Auditorium	1,000,000
An estimate shows that the construction of the exposition can be cared for with	12,000,000
Allowed for contingencies	600,000
Total	$17,250,000

Charles C. Moore, president of the Exposition company, states that there are 8000 business men in San Francisco who have not contributed to the Exposition fund, and it is proposed, by energetic solicitation, to obtain sufficient additional funds so that the Exposition may open its doors free from debt.——A bill has been introduced in the House of Representatives by William A. Rodenburg, Representative from Illinois, appropriating $2,000,000 for a Federal exhibit and buildings.——The Chamber of Commerce of Oakland, through its attorney, has arranged to introduce an enabling act at the present session of the state legislature which will authorize Alameda county to call an election to issue bonds in the amount of $1,000,000 for the purchase of Panama-Pacific Exposition stock.——The city of San Francisco has paid into the hands of the controller of the Exposition company $533,599, which is the first instalment of the $1,000,000 bond issue voted by the city as a contribution to the Exposition funds.

Catalogues Received

General Electric Co. New publications: Bulletin A4065, 'Electric Fans,' 36 pp., illustrated in colors; descriptive of various types of fans, and wiring devices for their use. Bulletin A4066, 'Electric Hardening Furnaces,' describing the operation, characteristics, and method of making connections. Bulletin A4063, 'Polyphase Induction Motors,' describing the characteristics and construction features in detail. Bulletin 4994, 'Type H, Form K Subway Transformers,' describing the characteristics of this transformer, which is similar in design to the type H, form K pole transformer, modified for subway service. Bulletin A4069, 'Portable and Stationary Air-Compressor Sets,' describes these interesting outfits, which are designed to meet the demands of factory service, power-stations, car-barns, etc., and are built in suitable sizes.

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Personal

ALEXANDER PEARSON, of Seattle, is making an extended Eastern trip.

HERBERT NUNN, city engineer of El Paso, Texas, has been in San Francisco recently.

BOWERMAN & MCCLOY have removed their offices to 911 Mutual Life building, Seattle.

ALEXANDER M. LUPFER has been appointed chief engineer of the Spokane Portland & Seattle railroad.

ERNEST B. HUSSEY, consulting engineer of Seattle, has gone to Juneau, Alaska, on professional business.

THEODORE HARDEE has been appointed chief of the Liberal Arts department for the Panama-Pacific Exposition.

J. W. STRACK is county engineer and C. A. MCCLUNG is chief deputy, with headquarters at Spokane, Washington.

ADOLPH JUDELL, assistant city engineer, San Francisco, has been appointed president of the Board of Public Works.

LORIN A. HANDLEY and EDWARD JOHNSON have been appointed members of the Los Angeles Board of Public Works.

A. M. YOUNG, formerly with the Seattle Construction & Dry Dock Co., is now associated with Reitze, Storrey & Duffy.

R. W. PACK, of the U. S. Geological Survey, has been inspecting the prospective oilfields in the vicinity of Barstow and Kramer.

E. A. MIDDLEBROOKS, consulting engineer of Portland, Oregon, is preparing plans for the construction of a logging road in Astoria county.

AUGUSTIN CRIFFIN, of Modesto, California, has been appointed irrigation manager of the Truckee-Carson project, succeeding H. W. MAREAN.

E. E. THORNTON, superintendent of transportation for the San Francisco-Oakland Terminal Railways Co., has gone East on an inspection trip.

J. F. Dodge, chief engineer for the Yolo Water & Power Co., has been inspecting the Moore and Capay dams in the vicinity of Woodland, California.

H. F. TUCKER, formerly of Boston, has opened consulting engineering offices in Seattle, specializing upon reinforced concrete and steel structures.

STANNARD & RICHARDSON, Henry building, Portland, Oregon, are making a valuation of the Elma, Washington, electric light plant and are reporting upon a lighting plant for Olympia, Washington. They also have under consideration the construction of a water-supply line 17 miles long for the Washington-Oregon Corporation.

F. L. PITMAN, with headquarters in Seattle, will supervise engineering work for the Oregon-Washington Railroad & Navigation Co.'s projected line from North Yakima to the coast.

JAMES R. MORRISON and GEORGE W. EVANS, of Seattle, have opened consulting engineering offices at 423 New York building, Seattle, specializing upon road pavement, street, and municipal work.

J. R. HOLMAN, chief engineer of the Oregon-Washington Railroad Co. in Seattle, has been transferred to Spokane to superintend the construction of the proposed union terminal station.

Col. THOMAS H. REES, engineer corps, U. S. A., accompanied by P. A. HAVILAND, county engineer, and J. J. JESSUP, city engineer of Berkeley, California, has inspected the proposed inland harbor site.

M. M. O'SHAUGHNESSY, city engineer of San Francisco, has been appointed by the Secretary of the Interior to serve with A. W. MALTBY in the investigation of the water-level situation at Lake Tahoe.

LOUIS C. KELSEY, of Portland, Oregon, has returned from Salt Lake City and has reported to the State Board of Health on the proposed water supply for the upper Wilamette cities from Springfield and Eugene to Salem.

CHARLES H. LEE, formerly in charge of Owens river water supply investigations for the Los Angeles aqueduct, has opened offices at 934 Union Oil building, Los Angeles, where he will engage in consulting practice, dealing especially with water supply problems.

HEINRICH HOMBERGER, consulting engineer, 864 Pacific building, San Francisco, has been appointed advisory engineer for hydraulic plant equipment by the Oro Electric Corporation in connection with the proposed 40,000 kva. power-plant on the north fork of the Feather river.

Society Meetings

The NORTHWEST SOCIETY OF ENGINEERS held its annual meeting at Seattle on January 4. R. H. Ober was elected president; Mervin Chase, vice-president; Joseph Jacobs, second

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vice-president; Sterling B. Hill, third vice-president; Jesse A. Jackson, secretary; W. N. Chase, treasurer; and C. E. Hill, librarian.

The fifth annual meeting of the ILLINOIS WATER SUPPLY ASSOCIATION will be held at the University of Illinois, Champaign-Urbana, March 11-12, 1913.

The ENGINEERS CLUB OF SEATTLE held its first annual banquet on January 11. The officers elected for the ensuing year were John C. Corbin, president; George B. Harrington, vice-president; J. T. Dovey, secretary, and Robert Howes, treasurer.

At the regular monthly meeting of the SPOKANE BRANCH OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS, D. L. Huntington, president of the Washington Water Power Co., and O. L. Waller of the State College at Pullman, discussed the general scope of the proposed water code of Washington, recommended by a commission appointed by the Governor. Morton Macartney, city engineer of Spokane, presided at the meeting.

The regular meeting of the UTAH SOCIETY OF ENGINEERS took place on January 17 in Salt Lake City. J. C. Howard, president of the Utah Oil Refining Co., read a paper dealing with petroleum crude oils and their refining value. F. J. Pack, professor of geology at the University of Idaho, gave an address on the geology of the oilfields of Utah. Meetings will be held on February 21, March 21, April 18, and May 16, at which general topics of interest to engineers will be discussed.

OREGON SOCIETY OF ENGINEERS has amalgamated with the ARCHITECTURAL CLUB OF PORTLAND, forming the OREGON TECHNICAL CLUB. This society has about 180 members and is affiliated with the INSTITUTION OF ENGINEERING SOCIETIES OF THE UNITED STATES. Addresses in preparation to be delivered before the club include a discussion of power possibilities in Oregon by J. H. Lewis, State Engineer, and the effect of deforestation on rainfall, by J. C. Stevens.

Commercial Paragraphs

The NORTHWEST OIL BURNER & EQUIPMENT Co. of Portland is building a 6-cylinder, 400-hp. gasoline engine.

SANDERSON & PORTER contemplate the installation of a 1500-kw. turbine, switchboard, and accessories, at Raymond, Washington.

D. W. TAYLOR, constructing engineer, of Portland, Oregon, has completed installation of gas and water mains and sewers at Oregon and King Heights, Portland.

KIBBE-WELTON Co., general contractors, of Portland, Oregon, have completed construction of the water-works at Elma, Washington; Newberg, and Riddle, Oregon.

HASSAM PAVING Co. of Worcester, Massachusetts, has published an illustrated booklet showing samples of pavement and describing in general the work done by this company.

EDWARDS & LAZELL, of Portland, Oregon, are testing 200,000 bbl. of cement which is to be used by the U. S. Government for the construction of the Lake Washington canal at Seattle.

MCCLURE, JONES & REED, 71 Broadway, New York, announce that they formed a co-partnership on January 1 for the transaction of a general investment and brokerage business in stocks and bonds.

The HILL HYDRAULIC MANUFACTURING CO., of Seattle, after two years of experimental work, has developed a new type of hydraulic ram that is said to be capable of operating successfully in large units.

The BUCYRUS COMPANY, manufacturers of excavating machinery, have recently changed their New York address to 30 Church street, New York City. C. S. Reed, Eastern sales manager, is in charge of this office.

The firm of EASTMAN, DILLON & Co., investment bankers of New York, was dissolved on January 1 and new co-partnership formed consisting of Thomas C. Eastman, Herbert L. Dillon, and Robert C. Mayer.

C. W. RIDDELL, consulting engineer, of Portland, Oregon, has completed surveys and plans for the development of 10,000 water-horse-power on the upper Deschutes river for the Pringles Falls Electric Power & Water Company.

E. L. WEBER, consulting engineer, Northern Bank building, Seattle, has completed plans and specifications for the electrical and mechanical equipment for the Weart building, Vancouver, and the provincial jail at Saanich, British Columbia.

L. F. HARZA & Co., including L. F. Harza and V. H. Reineking, have opened offices at Portland, Oregon, for the purpose of engaging in consulting, designing, and supervising engineering practice, specializing on irrigation projects and hydraulic-power developments.

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